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ABSTRACT

An effective curriculum gives students the opportunity to perceive relationships among different topics in mathematics, use mathematics in their everyday lives, and apply mathematical thinking and problem solving to other curriculum areas. This book contains fun and creative ways to integrate mathematics across the curriculum with a diversity of areas. The units in this book fall into two main categories: those adapting the integrated model where extensive team planning and a supportive schedule is needed and those adapting a modified version of the shared model where team planning is still necessary but traditional schedules will support the activities. Each unit accents the multiple intelligences that are addressed in the investigation and alternatives to traditional assessment. Chapters include: (1) "Our Earth: Natural Disasters"; (2) "Local River Inquiry: Interdisciplinary Unit"; (3) "Botany and Mathematics"; (4) "The Stock Market"; (5) "Quilting across the Curriculum"; (6) "Out in Space"; (7) "Our Human Body"; (8) "Physics and Formulas"; (9) "Gulliver's Travels"; (10) "In Two Dimensions"; (11) "Tiling and Tessellations"; (12) "Designs in Regular Polyhedra"; and (13) "Origami, Music, and Math". Included are charts of integrated topics, multiple intelligences, and National Council of Teachers of Mathematics' (NCTM) Standards. Appendices include plans to design lessons and answers to selected problems. Contains 26 references. (JRH)

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Hope Martin

Foreword by
Madeleine J. Long

NCTM-Aligned Activitie

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This book is dedicated to all of the teachers who have asked, "When am I going to have the time to teach this?" Perhaps it will give you some strategies to persuade the science, social studies, and language arts teacher to "share some of their time!"

Acknowledgments

I learned much from my teachers, more from my colleagues, and most from my pupils.

—Judah KaNasi
Talmud: Taanit, 7a

When I reflect upon the people and circumstances that brought me to this place, I must credit my own teachers, my talented colleagues, and the thousands of students who have entered my classroom, stayed for a short while, and then went on to bigger and better things.

It seems as if I have been going to school forever. My teachers shared their knowledge with me and the most skillful of them encouraged me to take their ideas and create my own knowledge.

For two decades, I have had the privilege of working with colleagues who have unselfishly shared their expertise with me. I have had the pleasure of working for many years with Lenore Mornini, our media area specialist, whose help I've asked for on many occasions. Without her assistance, I could not have put together the extensive reading lists in this book. Thank you, Lenore. To my team members—Joel Goldberger and Marge Baracan—who helped develop the best of the integrated activities in this book, thank you.

And to all of the students who shared about 1 percent of their lives with me and kept me young and anxious to continue to learn and grow, thank you. You have taught me the truth of what Einstein once said: "It is the supreme art of the teacher to awaken joy in creative expression and knowledge."

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Chart of Integrated Topics

	Art	Language Arts	Literature	Mathematics	Music	Science	Social Studies
Earthquakes		●	●	●		●	●
Volcanoes		●	●	●		●	●
Hurricanes		●	●	●		●	●
Tornadoes		●	●	●		●	●
Rate of the River		●	●	●	●	●	●
How Far across the River?		●	●	●	●	●	●
Depth of the River		●	●	●	●	●	●
Rate of Flow of the River		●	●	●	●	●	●
Temperature of the River		●	●	●	●	●	●
Statistics and Variation	●	●	●	●		●	●
Investing in the Market		●	●	●			●
First Week to Buy Stock		●	●	●			●
Week-to-Week Stock Market		●	●	●			●
Sell Week		●	●	●			●
Buy Week		●	●	●			●
The Mathematics of Quilts	●	●	●	●			●
Rocket Altitude Records		●	●	●		●	●
Driving to the Sun		●	●	●		●	●
The Body's Ratios				●		●	
Our Remarkable Heart				●	●	●	

(Continued on next page)

Chart of Integrated Topics *(Continued)*

	Art	Language Arts	Literature	Mathematics	Music	Science	Social Studies
The Thighbone's Connected to the . . .				●		●	
How Long Is Your Digestive System?				●		●	
What Are Your Favorite Foods?				●		●	
Sports Balls and Density		●	●	●		●	●
Roller Coasters and Acceleration		●	●	●		●	●
Roller Coasters and G-Force		●		●		●	
Traveling to Lilliput		●	●	●			●
A Look at Flatland		●	●	●			●
Semiregular Tessellations	●	●	●	●			●
Plato and Palindromes	●	●	●	●			●
The Musical Balloon	●	●	●	●	●		●

Chart of Multiple Intelligences

	Bodily/Kinesthetic	Interpersonal	Intrapersonal	Logical/Mathematical	Musical/Rhythmic	Verbal/Linguistic	Visual/Spatial
Earthquakes	●	●	●	●		●	●
Volcanoes	●	●	●	●		●	●
Hurricanes	●	●	●	●		●	●
Tornadoes	●	●	●	●		●	●
Rate of the River	●	●	●	●	●	●	●
How Far across the River?	●	●	●	●	●	●	●
Depth of the River	●	●	●	●	●	●	●
Rate of Flow of the River	●	●	●	●	●	●	●
Temperature of the River	●	●	●	●	●	●	●
Statistics and Variation	●	●	●	●		●	●
Investing in the Market	●	●	●	●		●	●
First Week to Buy Stock	●	●	●	●		●	●
Week-to-Week Stock Market	●	●	●	●		●	●
Sell Week	●	●	●	●		●	●
Buy Week	●	●	●	●		●	●
The Mathematics of Quilts	●	●	●	●		●	●
Rocket Altitude Records	●	●		●		●	●
Driving to the Sun	●	●	●	●		●	●
The Body's Ratios	●	●	●	●		●	●
Our Remarkable Heart	●	●	●	●	●	●	●

(Continued on next page)

Chart of Multiple Intelligences *(Continued)*

	Bodily/Kinesthetic	Interpersonal	Intrapersonal	Logical/Mathematical	Musical/Rhythmic	Verbal/Linguistic	Visual/Spatial
The Thighbone's Connected to the . . .	●	●	●	●			●
How Long Is Your Digestive System?	●	●	●	●			●
What Are Your Favorite Foods?		●	●	●		●	●
Sports Balls and Density	●	●		●		●	●
Roller Coasters and Acceleration	●	●		●		●	●
Roller Coasters and G-Force		●		●			●
Traveling to Lilliput	●	●	●	●		●	●
A Look at Flatland	●	●	●	●		●	●
Semiregular Tessellations	●		●	●		●	●
Plato and Palindromes	●	●	●	●		●	●
The Musical Balloon	●	●	●	●	●	●	●

Chart of NCTM Standards

	Algebra	Computation and Estimation	Geometry	Mathematical Connections	Mathematics as Communication	Mathematics as Problem Solving	Mathematics as Reasoning	Measurement	Numbers and Number Relationships	Number Systems and Number Theory	Patterns and Functions	Statistics and Probability
Earthquakes		●	●	●	●	●	●	●	●	●		●
Volcanoes		●	●	●	●	●	●	●	●	●		●
Hurricanes		●	●	●	●	●	●	●	●	●		●
Tornadoes		●	●	●	●	●	●	●	●	●		●
Rate of the River	●	●	●	●	●	●	●	●	●		●	●
How Far across the River?	●	●	●	●	●	●	●	●	●		●	●
Depth of the River	●	●	●	●	●	●	●	●	●		●	●
Rate of Flow of the River	●	●	●	●	●	●	●	●	●		●	●
Temperature of the River	●	●	●	●	●	●	●	●	●		●	●
Statistics and Variation	●	●		●	●	●	●	●	●	●	●	●
Investing in the Market	●	●	●		●	●	●		●	●		
First Week to Buy Stock	●	●	●		●	●	●		●	●		
Week-to-Week Stock Market	●	●	●		●	●	●		●	●		
Sell Week	●	●	●		●	●	●		●	●		
Buy Week	●	●	●		●	●	●		●	●		
The Mathematics of Quilts		●	●	●	●	●	●	●	●		●	
Rocket Altitude Records	●	●		●	●	●	●		●	●		●

(Continued on next page)

Chart of NCTM Standards

(Continued)

	Algebra	Computation and Estimation	Geometry	Mathematical Connections	Mathematics as Communication	Mathematics as Problem Solving	Mathematics as Reasoning	Measurement	Numbers and Number Relationships	Number Systems and Number Theory	Patterns and Functions	Statistics and Probability
Driving to the Sun		●		●	●	●	●		●	●	●	
The Body's Ratios		●	●	●	●	●	●	●	●	●	●	●
Our Remarkable Heart		●		●	●	●	●	●	●		●	●
The Thighbone's Connected to the . . .		●		●	●	●	●	●	●		●	●
How Long Is Your Digestive System?		●		●	●	●	●	●	●		●	●
What Are Your Favorite Foods?		●		●	●	●	●			●		●
Sports Balls and Density	●	●	●	●	●	●	●	●	●	●		●
Roller Coasters and Acceleration	●	●		●	●	●	●	●	●	●	●	●
Roller Coasters and G-Force	●	●	●	●	●	●	●		●	●	●	
Traveling to Lilliput		●		●	●	●	●	●	●	●		●
A Look at Flatland		●	●	●	●	●	●	●	●		●	●
Semiregular Tesselations		●	●	●	●	●	●	●			●	
Plato and Palindromes			●	●	●	●	●	●			●	
The Musical Balloon			●	●	●	●	●	●	●			

Foreword

More than 2,500 years ago the philosopher Pythagoras put forth the notion that all the world could be understood through numbers and mathematical principles. It was this idea that enabled Pythagoras to discover a hidden order and consistency in the world that simply needed to be disclosed. For example, a tree was not simply a tree to Pythagoras, but rather a complex relationship of measures and numbers that reflected an arc, circumference, and radius that was repeated in all of nature. Through mathematics Pythagoras discovered a hidden order in the world. Mathematics had awakened the world and, in turn, the world awakened mathematics.

Hope Martin has embarked on a similar project. In *Integrating Mathematics across the Curriculum* she discovers fun and creative ways to breathe life into the curriculum by integrating mathematics with a diversity of areas—from botany to the human body, from volcanoes to the stock market. In a very real way, she defines and illustrates a mathematics curriculum that can stretch across disciplines, effectively showing students how mathematics is intricately involved in almost all areas of life. Conversely, her technique for integrating mathematics across disciplines awakens the mathematics curriculum by fusing mathematics with "real-world" problems and applications through interactive, interesting, and productive activities.

Hope Martin's approach is clearly in line with those student-learning objectives defined in the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics*. In fact, the approach directly fosters the

Standards' five general goals for all students:

(1) that they learn to value mathematics;
(2) that they become confident in their ability to do mathematics;
(3) that they become mathematical problem solvers;
(4) that they learn to communicate mathematically; and
(5) that they learn to reason mathematically.

Each investigation in this book is clearly formulated with both the teacher and the student in mind; each contains thorough instructions which permit the teacher to implement and assess each activity and also offers suggestions for further reading. The book allows teachers room to elaborate further on each investigation and encourages them to create their own investigations. This book will come as a valuable resource to the many teachers who are seeking new and productive ways to engage their students in mathematics. I took delight in doing some of the exercises Ms. Martin proposes in *Integrating Mathematics across the Curriculum* and am certain that you and your students will as well.

Madeleine J. Long
Vice President
The Implementation Group

Introduction

Mathematics—
The Key to Opportunity

We have seen our modern world change from being in the industrial to the information age in less than one generation. Mathematics and science have become important keys to opportunity. A substantive knowledge of mathematics is important in many fields. It is the language of science, the key to business and finance, and an essential element in understanding the technology of change. It helps us interpret the world around us. In its discussions of the importance of mathematics in today's world, the Mathematical Sciences Education Board (1989) stated, "The cycle from data to deduction to application recurs everywhere mathematics is used, from everyday household tasks, such as planning a long automobile trip to major management problems such as scheduling airline traffic or managing investment portfolios" (p. 31). While an understanding of mathematical and statistical concepts separates the "numerate" from the "innumerate," the number of students who leave school with an adequate understanding of math has been declining over the past twenty years. Because of this disparity between society's needs and the success of students in mathematics, the curriculum (what is taught) and the pedagogy (how it is taught) has been the focus of research for a period of time.

Research shows that when children enter school, many have had experience using mathematics in their "real world." They have shared equally, counted their toys and judged who has the most, and "calculated" how many more marbles they need to get to a particular number. These children do not perceive mathematics as an isolated subject with rules and procedures, but as a useful and efficient way to quantify and understand their world.

When they enter a classroom where the primary focus is the memorization of arithmetic facts, and there is a preoccupation with learning rote, lower-level computational skills, children may lose their belief that mathematics "makes sense." They become passive recipients of isolated rules rather than active participants in connected learning. "School math" and "real math" become disconnected; students' curiosity and interest decline. What must be done to maintain the students' belief that mathematics is important—a vital and meaningful tool to help interpret and quantify our modern world? We must make connections between mathematics and other curricular areas and plan for an integrated model of teaching.

INTEGRATING THE CURRICULUM: MAKING CONNECTIONS

> *Mathematical things—numbers, statistics, fractals, cyberspace, dimensions, polyhedra, tessellations—have a pervasive way of creeping into our everyday experiences until the objects seem to become household terms. How does this happen? Through comments made by newscasters, statespeople, artists, writers, philosophers, scientists, musicians, architects, people in all areas of life. Why? Because mathematical things help to measure, describe, predict, and quantify so many facets of our lives. Be it things that deal with our bodily functions, our economics, our environment, politics—almost anything you can name will some way have mathematics connected to it. Name ten things you use or do in a day and see how many of these have something mathematical linked to them.*
>
> —Theoni Pappas
> *The Music of Reason*

How do we bring into the mathematics classroom this idea of the pervasiveness of mathematics in the real world? The National Council of Teachers of Mathematics (NCTM 1989) has defined mathematical connections as one of its four primary standards. Curriculum should be designed so that students are given the opportunity to perceive relationships among different topics in mathematics, use mathematics in their everyday lives, and apply mathematical thinking and problem solving to other curriculum areas.

Perhaps part of the problem rests with the design of the curriculum. Fogarty (1991) states, "The traditional curricular arrangement dictates separate and distinct disciplines. . . .

In the standard curriculum, . . . subject matter areas are taught in isolation, with no attempt to connect or integrate them" (p. 4). Research shows that students construct knowledge from previous knowledge and experiences. Fragmentation, rather than integration, makes it more difficult for students to make connections and, therefore, to construct new knowledge and transfer it to unique situations.

Fogarty (1991) describes ten curricula models that move toward an integrated curriculum:

1. Fragmentation: A narrow focus related to a single discipline.
2. Connected: Details of one discipline; the focus is on interconnections.
3. Nested: An examination of multiple dimensions of one topic or unit.
4. Sequenced: Varied internal content framed by broad, related concepts.
5. Shared: Two disciplines share overlapping concepts and skills.
6. Webbed: One theme is webbed through multiple disciplines; the initial focus is on the theme—the curriculum follows.
7. Threaded: A metacurricular approach is taken to magnify the big idea.
8. Integrated: An interdisciplinary approach is taken where the initial focus is on the curriculum and the integration flows from curricular topics and concepts.
9. Immersed: All disciplines are filtered through the lens of the learner's interest.
10. Networked: A view that creates multiple dimensions and directions of focus.

Integrating Mathematics across the Curriculum will adapt two of Fogarty's ten models, the shared and integrated models. The use of the Venn diagram (showing the intersection of sets) visually describes the interrelationship between curriculum and pedagogy.

The units in this book fall into two main categories: (1) those adapting the integrated model, where extensive team planning and a supportive schedule is needed, and (2) those adapting a modified version of the shared model, where team planning is still necessary but traditional schedules will support the activities.

MULTIPLE INTELLIGENCES: AN IMPORTANT COMPONENT OF THE ISSUE

Using activities and projects that cross curricular boundaries to teach mathematics encourages students to be active rather than passive learners. They work together, discuss ideas, plan strategies, compromise, and draw conclusions based on a wide range of interests and perspectives. Students are free to utilize learning styles that are compatible with their ways of knowing. Howard Gardner (1983) presented a theory that there are seven intelligences, not just one or two. Here are the seven intelligences described by Gardner:

1. Verbal/linguistic intelligence: People who possess this intelligence to a heightened degree have a strong sensitivity to the meaning of words, are able to communicate effectively, and are generally comfortable using language in verbal and written form.

2. Musical/rhythmic intelligence: Each of us holds musical capabilities to some degree. In some societies, students are encouraged to develop their musical intelligence (e.g., Japan's Suzuki method of teaching violin). People with a highly developed musical/rhythmic intelligence enjoy and understand music and may become singers, composers, or conductors.

3. Logical/mathematical intelligence: People who have a strong propensity for mathematics are typically characterized by a love for the problem-solving process, using patterns, reasoning, and symbolic abstractions. Mathematics can be divided into two branches: applied and theoretical. It is the field of applied mathematics that encourages us to solve problems in the "real world," but it is the field of theoretical mathematics that builds

theories and tests them with abstract logic. Both are essential contributors to our body of mathematical knowledge, but it is the applied mathematics that brings mathematics to life in the classroom.

4. Visual/spatial intelligence: People with a strongly developed visual/spatial intelligence have the ability to accurately and effortlessly understand their physical world. Research has indicated that students who have a strongly developed spatial intelligence find math less threatening and are better math students.

5. Bodily/kinesthetic intelligence: People with a strong bodily/kinesthetic intelligence have the ability to "use one's body in highly differentiated and skilled ways . . . to work skillfully with objects, both those that involve the fine motor movements of one's fingers and hands and those that exploit gross motor movements of the body" (Gardner 1985, 206).

6. Intrapersonal intelligence: Understanding and being in touch with one's feelings and thoughts are at the center of this intelligence. By encouraging students to explain their reasoning and thinking, they become more self-reflective.

7. Interpersonal intelligence: Sensitivity to others and the world around them is the trademark of those who possess interpersonal intelligence to a high degree. The traditional mathematics classroom is usually more competitive than collaborative in nature.

Each of the units presented in *Integrating Mathematics across the Curriculum* accents the multiple intelligences that are addressed in the investigation.

ALTERNATIVES TO TRADITIONAL ASSESSMENT

When instruction engages students as active participants rather than passive learners, teachers need to look beyond traditional assessment strategies and move toward a more multifaceted assessment that accurately describes where the student is at. Performance assessment, sometimes referred to as authentic assessment, requires students to perform tasks, create products, or problem solve multistep, nontraditional mathematics tasks. Such tasks cannot be "graded" right or wrong; they cannot be evaluated using traditional methods.

By expanding their repertoires and incorporating performance assessments, teachers can do the following:

- Make mathematical tasks more authentic (align the assessment to the curriculum).
- Engage the students in thought-provoking, meaningful mathematics.
- Make students active participants in the learning process.
- Plan activities and projects that allow students to work together and foster their multiple intelligences.
- Encourage students at different cognitive levels and with different learning styles to collaborate and share their strengths with one another.

Performance assessment may take the form of journals, student products, completion of tasks, or open-ended problems. Students may be asked to present their ideas or conclusions in verbal or written form. Good assessment is designed to be congruent with the particular mathematical task. It encourages students to use strategies that are appropriate for the activity, helps foster persistence, encourages thinking in a variety of styles, and allows for multiple avenues to approach a problem (making it accessible to more students).

Rubrics are scoring scales used to evaluate a student's performance based on levels of degrees of mastery. Learning is considered a continuous process that takes place over a period of time. Here is an example of a problem-solving rubric:

4	3	2	1	0
Fully Developed Solution	Developed Solution	Partially Developed Solution	Under-Developed Solution	No Attempt Made

What are the characteristics of a good rubric? First, the criteria align with the curriculum and method of instruction. Once you know what it is that you want to teach and what you want your students to learn, you are ready to develop your assessment criteria. Think of your students' progress on a continuum from least developed to most developed and have a clear understanding of the performance levels between these two extremes.

Mathematics rubrics should address three main areas of knowledge and the degree to which they are demonstrated:

- Knowledge: An understanding of mathematical concepts and procedures is present.
- Integration of concepts: The strategies utilized show evidence of knowledge.
- Mathematical communication: There is a clear written explanation and rationale for the solution process.

By incorporating these three aspects of performance on a grading matrix, an analysis of the parts can be incorporated into a holistic view of the students' progress. Many of the activities in this book have grading matrices utilizing these criteria in their design. Each activity has been analyzed to report the following:

1. Did the student understand the concepts? Is the computation correct? What strategies were used?
2. What was the overall quality of the project? Did the student show his or her ability to integrate the knowledge?
3. How well did the student explain (in written or graphic form) the mathematical concept?

Not all of the activities have grading matrices, however. A "design your own" grading matrix that you can adapt to these activities is found in Appendix A. As you revise and mold the ideas in this book to suit your own curricular needs, keep assessment an integral part of the planning process. Rather than being the end of a lesson, it should be a meaningful element of instruction.

WHAT DOES THIS BOOK CONTAIN?

Shared and Integrated Explorations

Fogarty (1991) describes the shared model in this way:

> Two members of the team approach the preliminary planning session with a notion of key concepts, skills, and attitudes traditionally taught within the single-subject approach . . . they look for overlaps in subject matter content. (p. 44)

Fogarty states that, in contrast, the integrated model:

> represents a cross-disciplinary approach similar to the shared model. The integrated model blends the four major disciplines by setting curricular priorities in each and finding the overlapping skills, concepts, and attitudes in all four. (p. 76)

In both of these models of integration, teachers start with the needs of their specific curricula and then pursue overlapping components.

The explorations in *Integrating Mathematics across the Curriculum* blend elements of both. Most of the investigations can be used as informal shared studies or can be expanded to include all curricular areas. Some, however, have been designed in the true integrated model. They require team planning and a more flexible schedule. The introductions included with each investigation describe the curricular connections and make suggestions for integration.

The Explorations

Most of the activities in this book follow the same model:

- Venn Diagram of Integration

  Each investigation begins with a diagram highlighting the interrelationship among curricular areas.

- The Teacher's Page

  1. Mathematical Connections: Principal mathematical skills and concepts are defined.

  2. Intelligences: Those multiple intelligences embraced in the exploration are listed.

3. Other Curricular Connections: A brief description of the curricular interrelationships of the lesson.
4. Concepts: The mathematical concepts are delineated in terms of student outcomes. A careful analysis of these concepts helps define the assessment.
5. Materials Needed: Before beginning the investigation, carefully check out the list of required materials.
6. Procedures: This is not meant to be a detailed, step-by-step analysis of the lesson. Rather it is a brief outline of the activity.
7. Assessment: Student products, observation of students, the grading matrix (based on a rubric), and journal questions give teachers a well-rounded picture of the nature of student understanding.

- The Investigation

  Following the teacher's page are the ready-to-use activities. The investigations are very different, but their purpose is to allow for active student involvement and curricular connections.

- The Grading Matrix

  Based on the assumption that all learning is on a continuum of mastery, the grading matrix incorporates the concept of a rubric. The criteria are based on the concepts delineated at the beginning of the lesson.

- Additional Reading

  Following most of the activities are suggestions of books that relate to the unit, which your students might enjoy. A brief description of each book is supplied.

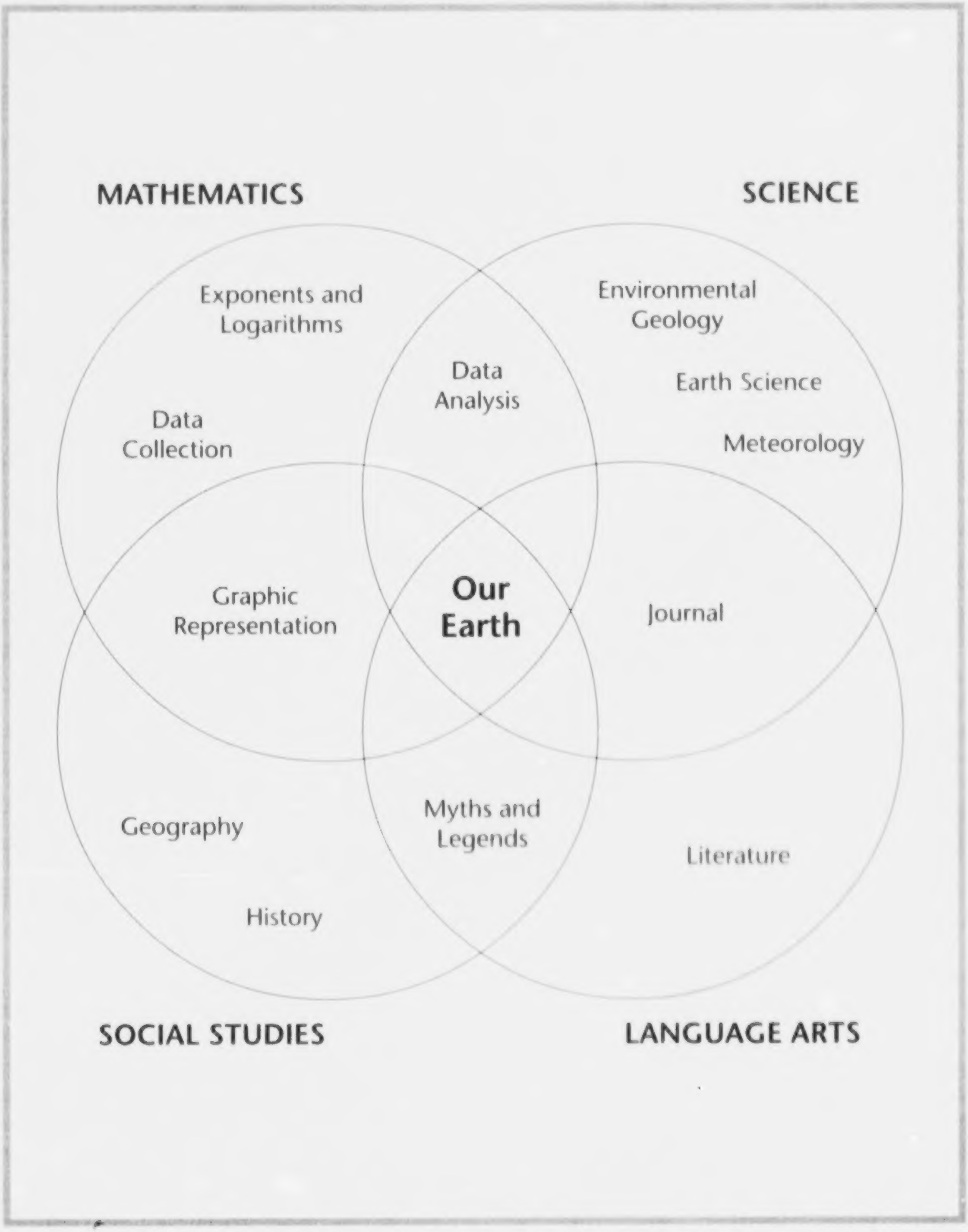
SECTION I

Integrated Explorations

CHAPTER 1

Our Earth

Natural Disasters


MATHEMATICS
SCIENCE
Exponents and Logarithms
Environmental Geology
Data Analysis
Earth Science
Data Collection
Meteorology
Graphic Representation
Our Earth
Journal
Geography
Myths and Legends
Literature
History
SOCIAL STUDIES
LANGUAGE ARTS

CHAPTER 1

Our Earth

Natural Disasters

> *The profound study of nature is the most fertile source of mathematical discoveries.*
>
> —Joseph Fourier

The study of natural disasters—including earthquakes, volcanoes, hurricanes, and tornadoes—extends across the disciplines. Their enormous power is awesome. We are all fascinated with such destructive natural forces, and this topic has built-in motivation for middle school youngsters. This unit has been subdivided into four powerful weather systems. In addition, some activities relate to more common weather phenomena, such as thunderstorms and lightning. Each of these weather topics will be examined with mathematics activities.

The first section examines some of the major earthquakes that have occurred in history. Although there are about a million earthquakes every year, most are so tiny that they barely register on a seismograph. But when more powerful earthquakes occur, they can destroy entire communities and be responsible for great loss of life.

In science, students examine what an earthquake is, the technology of its measurement, and scientists' attempts to predict when they will occur. The study of the earth's layers and the movement of plates brings excitement to geology.

The history of earthquakes and the lands most affected by their destructive power constitute a substantial lesson in social studies. Ninety percent of all earthquakes occur in the "ring of fire," which encircles the Pacific Ocean. The countries that make up the ring of fire are an integral part of the middle school social studies curriculum.

The myths and legends surrounding earthquakes date back thousands of years. According to Hindu mythology, earthquakes occurred when one of the eight elephants who carried the earth on their backs became tired. Japanese legend blamed earthquakes on a giant catfish, the Namazu, which lived beneath the mud. These tales form a fascinating collection of stories for students. As a matter of fact, earthquakes can form an exciting topic for middle school curricula integration.

In mathematics, students are exposed to a real-world application of logarithmic numbers. Earthquakes are measured using a scale developed by Charles Richter, called the Richter scale. The numbers on the scale express the amount of energy released at the focus of an earthquake. Starting at 1, each number on the scale is 10 times more powerful than the one before it. The scale is logarithmic, based on exponents with a base of 10. For example, the difference between 5.0 and 7.0 on the Richter scale is not 2 but 10^2, or 100 times more powerful. A magnitude of 7.0 on the Richter scale has the destructive power of a one-megaton nuclear bomb.

The great San Francisco earthquake of 1906, which leveled the city, had a magnitude of 8.3 on the Richter scale. Even more powerful earthquakes have been recorded during the twentieth century. An example of the magnitude and strengths of earthquakes can be seen in the table on page 17.

Earthquakes with magnitudes of 5.8 can cause great damage if they appear in remote, yet populated, areas. In 1990, an earthquake with a magnitude of only 5.8 killed more than one hundred people and left hundreds missing when villages in the forest regions of Peru were flattened or swallowed up by landslides.

There are more than six hundred active volcanoes on Earth. More than half of them are found in the same area that the most powerful earthquakes occur—in the ring of fire. The myths and legends surrounding volcanoes are even more far-reaching than those about earthquakes. Primitive tribes paid tribute to the power of volcanoes by making sacrificial offerings to them. Literature abounds with stories of the volcanoes' staggering power, and, since major active volcanoes are located on every continent, there are obvious ties to social studies.

Richter Number	Magnitude (Multiple of 10)	Just How Powerful Is That?
1	1	Can't even feel this one, but it will be recorded on a seismograph.
2	10	Very, very weak—almost the same as a recording of 1 on the Richter scale.
3	100	Still very weak; anything less than 3.5 cannot be felt but will register on a seismograph.
4	1,000	Although weak, it can be felt. It has the magnitude of a heavy truck passing by.
5	10,000	Getting stronger. You can feel the rumblings and dishes will fall and break.
6	100,000	Buildings will shake; roads and walls will crack.
7	1,000,000	Many buildings will be destroyed; crevices will appear in the earth. People will be hurt and many will be killed.
8	10,000,000	Few buildings will be left standing. There will be great devastation and loss of life.
9	100,000,000	It is believed that the earthquake that accompanied the volcano eruption on the island of Krakatau in 1883 would have registered 9.9 on the Richter scale. The island of Krakatau sank.

The power of volcanoes hits close to home. On a sunny Sunday morning in May 1980, the eruption of Mount St. Helens in Washington State changed a magnificent snow-capped mountain surrounded by luxuriant forests into a barren wasteland. The blast tore away a portion of the mountain peak equal in height to the Empire State Building and killed more than two million animals and about sixty people. The mathematics activities in this section of the chapter have been designed to help students understand this devastating power.

The word *hurricane* is derived from the name of the West Indian god of storms, Huracan. These tropical storms have local names, depending where they originate. In the Pacific, they are called typhoons; in the Atlantic, hurricanes; in the Indian Ocean, cyclones; and in Australia, willy willies.

Hurricanes develop every year when the summer sun heats the water in tropical oceans. If the water warms to more than seventy-five degrees, whirlwinds form; some disappear harmlessly while others combine to form tropical storms with speeds of more than 200 miles per hour. Their clouds carry billions of tons of water that has evaporated from the ocean. This water, when dumped on land, can cause floods and incredible damage.

Meteorology is a significant part of the middle school science curriculum. By studying the anatomy of hurricanes and typhoons, following the development of tropical storms, and keeping a "hurricane watch," students find the study of weather a fascinating topic in their science and social studies classes. In the mathematics class, students learn to appreciate the power of tropical storms by working through mathematical activities.

And finally, what student hasn't heard of Dorothy's trip from Kansas to the Land of Oz on the winds of a tornado? Mathematics and science lessons begin in the literature class! Interestingly, the whirling motion of a tornado, called a vortex, is the most efficient method found in nature of shifting liquids and gases in a hurry. A vortex is exemplified by the "spinning skater effect." As a spinning skater draws up her arms (and forms the shape of a tornado), she spins more rapidly. The winds of tornadoes are the fastest on Earth. And unlike the events in *The Wizard of Oz,* real tornadoes roar like freight trains, whip out of clouds, and when they reach the earth's surface, cause destruction of enormous proportions. Over water, the spinning storms create enormous water spouts. In deserts, the spinning air columns produce dust devils, and over land the columns act as giant vacuum cleaners, sucking up everything in their paths.

"Our Earth: Natural Disasters" is an interdisciplinary unit rich in connections between language arts, social studies, science, and mathematics. Meet with your team and develop the cross-curricular relationships that best meet the needs of your school.

Earthquakes

MATHEMATICAL CONNECTIONS

exponential notation, subtracting and rounding decimals, volume

INTELLIGENCES

logical/mathematical, bodily/kinesthetic, visual/spatial, verbal/linguistic, interpersonal

OTHER CURRICULAR CONNECTIONS

Science: Earth science, environmental geology

Social Studies: Geography, history

Language Arts: Literature, myths and legends, creative writing

CONCEPTS

Students will do the following:

1. Compute the difference in magnitude of exponential numbers
2. Subtract decimals
3. Use scientific calculators to compute differences in magnitude

MATERIALS NEEDED

scientific calculators (10^x or y^x key is needed); copies of all earthquake blacklines

PROCEDURES

The mathematics part of the study of earthquakes includes applying a seldomly used notation—logarithmic numbers. These are actually powers of ten. For example: $10^2 = 100$; the log of $100 = 2$.

Read and discuss the example on the "Magnitude of Earthquakes" blackline with the students. To compute the difference in magnitude, merely subtract the exponents. For example, an earthquake with a magnitude of 5 could be written as 10^5. An earthquake with a magnitude of 7 could be written as 10^7. The difference is 10^2, or 100 times the magnitude. Students will need to use calculators to compute the difference of magnitude when the exponents are decimal fractions.

For the second lesson, place students into groups of 5 to 6. Refer the students to the "How Deep Is Deep?" blackline and have them problem solve the answer to the question. Be sure to make time for students to explain how they solved the problem. It should be interesting to learn of the different ways students think about the solution.

ASSESSMENT

1. Student products—Successful completion of lesson
2. Observation of students
3. Grading matrix
4. Journal question: "Explain the difference in magnitude between an earthquake in China registering 8.5 on the Richter scale and one in California registering 6.6."

Magnitude of Earthquakes

Names ______________________________

Date ____________________ Class ____________________

The difference in magnitude of earthquakes can be expressed as exponents with a base of 10. For example: There are two earthquakes, one with a magnitude of 5 and the other 7; the difference is 2. This means that one of these earthquakes is 10^2, or 100 times as powerful as the other. On the table below are ten of the most powerful earthquakes of the twentieth century. The difference between 8.9 and 8.6 is 0.3. Using a calculator, we find that $10^{0.3} = 2$. This means that an earthquake registering 8.9 on the Richter scale is twice as powerful as one that registers 8.6. Use your calculators to answer the questions below.

Most Powerful Earthquakes of the Twentieth Century

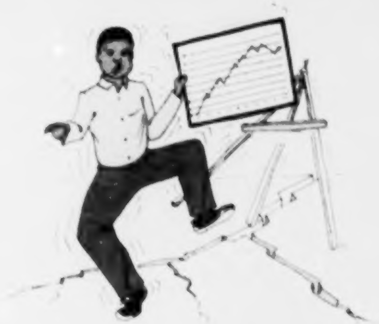
Year	Location	Richter Scale
1906	Coast of Columbia	8.9
1906	Jammu and Kashmir, India	8.6
1906	Valparaiso, Chile	8.6
1920	Gansu, China	8.5
1929	Fox Island, Alaska	8.9
1933	North Honshu, Japan	8.9
1941	Portugal	8.4
1950	Assam, India	8.3
1960	Lebu, Chile	8.5
1964	Prince William Sound, Alaska	8.9

1. How much more powerful is an earthquake that registers 8.9 on the Richter scale than one that registers 8.3? ______________________________

2. In December 1989, a fatal earthquake hit Australia for the first time. While it only registered 5.5, 12 people were killed and 120 injured. How much more powerful is an earthquake registering 8.9 than one registering 5.5? ______________________________

3. How much more powerful was the earthquake off the coast of Columbia than the one in Valparaiso, Chile? ______________________________

4. In 1976, an earthquake in Tangshan, China, measured 7.9 on the Richter scale. The death toll has been estimated at about 250,000 people. How much more powerful was the earthquake that occurred in 1920 in Gansu? ______________________________



How Deep Is Deep?

Names ______________________________

Date ______________ Class ______________

The 1964 earthquake that occurred in Prince William Sound, Alaska, lasted for 7 minutes. During this earthquake, the ground rolled like waves on the ocean and huge cracks opened in the ground. Just how deep? Some cracks were 3 feet wide and 40 feet deep! Many buildings fell over into these deep crevices.

Question: If the crack in the earth was a square prism with sides of 3 feet and a depth of 40 feet, what would be the volume of this hole? How many students would fit in a hole this size? Work with your classmates to find a solution to this problem. Write your solution in the space provided.

Our Solution

The approximate number of students:

The volume of the hole:

A description of our reasoning:

Grading Matrix

Names ______________________________

Date ______________ Class ______________

Criteria	4	3	2	1
Accuracy of computation				
Quality of group activity				
Quality of written responses				
Overall quality of project				
Comments:				

Volcanoes

MATHEMATICAL CONNECTIONS

data collection, ratio and proportion, scale drawing, computation, English measurement

INTELLIGENCES

logical/mathematical, verbal/linguistic, visual/spatial, bodily/kinesthetic, interpersonal

OTHER CURRICULAR CONNECTIONS

Science: Meteorology, Earth science, environmental geology

Social Studies: Geography, current events

Language Arts: Myths and legends, creative writing

CONCEPTS

Students will do the following:

1. Develop a conceptual understanding of the magnitude of the force of volcanoes through mathematical activities
2. Use English measurements of length to compute distance and rate

3. Use ratio and proportion to design a scale drawing of the world's volcanoes

MATERIALS NEEDED

rulers and yardsticks; maps; calculators; copies of all volcano blacklines; colored pencils or markers

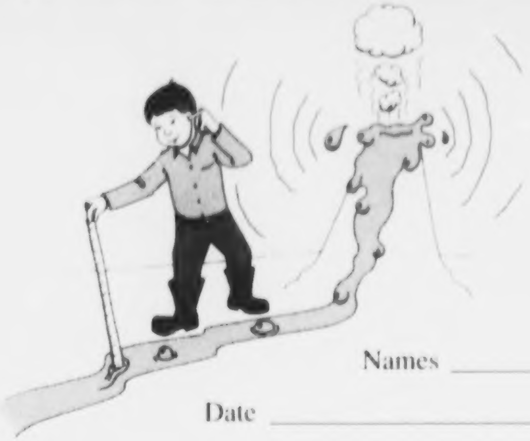
PROCEDURES

Discuss with students the power of volcanoes using some of the information supplied in the introduction to this unit. Give the students facts. For example, ask them, "Did you know that when Mount St. Helens erupted in Washington state, a piece the size of the Empire State Building was blown off the top?" Other interesting facts can be found in any book about volcanoes.

The mathematics lessons are divided into two parts. For the first lesson, "Some Interesting Facts about Volcanoes," students should work in groups of four. The answers should be a consensus of the group—the results should come from group discussion and collaboration. The second lesson is a solitary one. Working alone, each student designs a "graph" of volcanoes using a scale of 1,200 ft = $^{1}/_{4}$ in. These drawings can be enhanced by using colored pencils or markers.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix



Some Interesting Facts about Volcanoes

Names ________________________________

Date ______________ Class ______________

1. Some lava flows can be 66 feet thick and take several years to cool. Work with your group of four to determine how many students, standing side by side, it would take to form a line 66 feet long.

   We decided it would take ____________ students to form a line 66 feet long.

   The way we solved this problem: ________________________________

   ____

   ____

2. The loudest sound ever recorded was in 1883. It was the eruption of a volcano on the island of Krakatau in the Pacific Ocean. The noise was heard in Australia (about 3,000 miles away).

   If sound travels at a speed of about one mile every five seconds, how long did it take for the sound to travel from Krakatau to Australia? (Be sure to use appropriate units of measure.)

   We decided it would take ____________ for sound to travel from Krakatau to Australia.

   The way we solved this problem: ________________________________

   ____

   ____

3. When Mount Tolbachik erupted in 1975, the lava gushed out at a speed of 550 feet per second.

   Express this speed in miles per hour. ________________________________

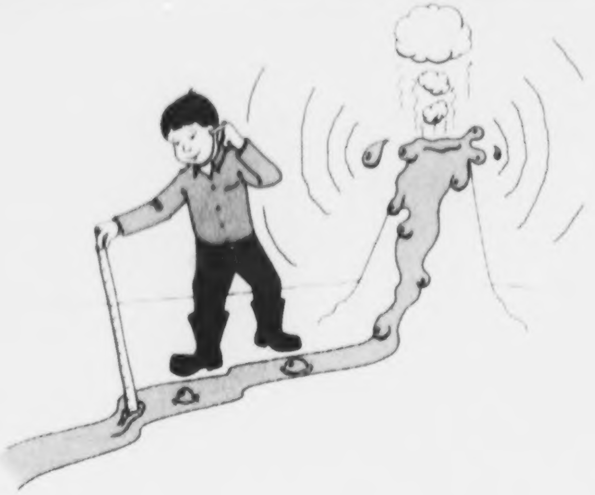
   If you were traveling at this speed in a car, where would you be after 1 hour? (Use a map to find the location.)

   We decided we would be at ________________________________

   The way we solved this problem: ________________________________

   ____

   ____



Volcanic Mountains Grid

Name ______________________

Date ______________________

Class ______________________

There are more than 600 active volcanoes on Earth. About half of these are located in the "ring of fire." The ring encircles the Pacific Ocean, both on land and underwater. Volcanoes are found on every continent:

Continent	**Country**	**Volcano**	**Height**
Africa	Zaire	Nyirangongo	11,546 ft
Antartica	Ross Island	Erebus	12,202 ft
Asia	Russia	Kluchevskaya	15,580 ft
Europe	Italy	Etna	10,955 ft
North America	United States	Mt. Wrangell	14, 006 ft
South America	Argentina	Antofalla	20,097 ft
Oceania	New Zealand	Ruapehu	9,174 ft

Use the grid on the next page to draw the height of each of these volcanic mountains to scale. Each of the squares on the grid is 0.25 inches. [1,200 ft = $\frac{1}{4}$ in]

(Continued on next page)

Volcanic Mountains Grid (Continued)

Grading Matrix

Name(s) ______________________

____

Date ______________________

Class ______________________

Criteria	4	3	2	1
Accuracy of computation				
Quality of written responses				
Overall quality of project				

Comments:

Hurricanes

MATHEMATICAL CONNECTIONS

English measurement conversions, computation, estimation

INTELLIGENCES

logical/mathematical, interpersonal, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Meteorology, Earth science, environmental geology

Social Studies: Geography, history, research

Language Arts: Literature, creative writing

CONCEPTS

Students will do the following:

1. Use English measurements to find the volume of large quantities of water
2. Use English measurements to find the weight of large quantities of water
3. Estimate the relative size of large quantities of water

MATERIALS NEEDED

calculators; world almanacs or world atlases; "How Much Water?" blackline for each group of students

PROCEDURES

Place students into groups of two to four and have them consider the power of hurricanes. Discuss how much water actually falls when one inch of rain uniformly falls on an area. How much does it weigh? What is its volume?

Use the information on the "How Much Water?" blackline to discuss how much one inch of water would weigh if the floor of your classroom were covered with rain. Let's assume your classroom is 30 ft x 30 ft.

One square mile contains 27,878,400 square feet. A classroom with the dimensions above is 900 square feet. One inch of water over 1 square mile of land equals 17,371,520 gallons. Using the decimal ratio, we find that the classroom would have about 521 gallons of water on the floor (0.00003 x 17,371,520). This much water would weigh about 4,324.3 pounds.

This exercise gives students an understanding of the large quantities of water that accumulate in three-dimensional spaces.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "If you had a 50-gallon fish tank in your bedroom, how much would the water inside it weigh? How could you compute the amount of weight exerted on each square foot of floor space?"

How Much Water?

Names

Date

Class

The most violent and powerful storms are called hurricanes if they occur over the Atlantic Ocean, typhoons if they occur over the Pacific Ocean, or cyclones if they occur over the Indian Ocean. All of these storms begin over warm waters. The wind speeds of hurricanes can reach more than 200 miles per hour, and their size can measure as much as 500 miles wide. Hurricanes contain enormous quantities of water.

How much water is an enormous amount of water? Let's examine this question. To do so you need to have a little information about the meaning of "one inch of rain."

1 inch of water on 1 square mile of land = 17,371,520 gal
1 gallon of water weighs ≈ 8.3 lb

Use this information to discover the awesome power of hurricanes and typhoons.

Fact:	A hurricane that hit Puerto Rico in 1928 dropped 30 inches of rain.
Question:	How much did the water weigh that fell on Puerto Rico? How many gallons of rain fell on Puerto Rico? (To answer this, you must know the size of Puerto Rico in square miles. You can use an atlas or world almanac.)
Fact:	In 1921, a hurricane in Texas deposited 23 inches of rain in a single day.
Question:	If there was a uniform amount of rain across the state, how many gallons of water fell and how much did they weigh? (To answer this, you must know the size of Texas in square miles. You can use an atlas or world almanac.)

Work with your group to estimate just how much water 17,000,000 gallons of water is. How does it compare with the amount of water in a bathtub? In a swimming pool? Describe your solution below:

Grading Matrix

Names ______________________________

____

Date ______________________________

Class ______________________________

Criteria	**4**	**3**	**2**	**1**
Accuracy of computation and research				
Quality of written responses				
Overall quality of project				

Comments:

SPEED
LIMIT
200

Tornadoes

MATHEMATICAL CONNECTIONS

English measurement, computation, estimation, using formulas

INTELLIGENCES

logical/mathematical, verbal/linguistic, interpersonal, bodily/kinesthetic

OTHER CURRICULAR CONNECTIONS

Science: Meteorology, Earth science, environmental geology

Social Studies: Geography, history, current events

Language Arts: Literature, myths and legends, creative writing

CONCEPTS

Students will do the following:

1. Calculate time knowing rate and distance
2. Estimate distance
3. Predict distance of lightning strikes based on time differential

MATERIALS NEEDED

calculators; yardsticks; tape measures; copies of "Interesting Facts" blackline

PROCEDURES

Discuss with students their impression of tornadoes based on their knowledge of *The Wizard of Oz*. Share with students the information supplied in the introduction to this unit.

The first lesson involves asking students to count the number of seconds between seeing lightning and hearing thunder. They occur at the same time; but, since sound travels much slower than light, we see the lightning before we hear the thunder.

$$\text{The speed of light} \approx \frac{186{,}000 \text{ miles}}{1 \text{ second}}$$

$$\text{The speed of sound} \approx \frac{1 \text{ mile}}{5 \text{ seconds}}$$

By dividing the number of seconds between the time lightning is seen and thunder is heard by 5, students can approximate how far away the lightning bolt struck.

ASSESSMENT

1. Student products—Successful completion of lesson and blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "Explain why we see lightning strike sooner than we hear the accompanying thunder."

SPEED
LIMIT
200

Some Interesting Facts about Tornadoes

Names ______________________________

Date ______________________ Class ______________________

Tornadoes are funnel-shaped storms that twist as air spins upward. This whirling motion, called a vortex, is the most efficient method found in nature to shift liquids and gases in a hurry. An example of how the vortex works is the "spinning skater effect." As a skater draws her arms upward, she turns more rapidly. In the center of tornadoes, winds can reach speeds of more than 250 mph.

Tornadoes form from thunderstorms, and with thunderstorms come lightning. The next time there is a storm with thunder and lightning, start counting the seconds that elapse between the time you see the lightning and the time you hear the thunder. By dividing the number of seconds by 5, you can compute how far away the lightning struck.

Read the following interesting facts about tornadoes and solve the problems.

1. On May 26, 1917, a single tornado traveled at an average speed of 65 mph for 293 miles.

   Work with your group of four to determine how many hours and minutes the tornado traveled.

   We decided it traveled ___________ hours and ___________ minutes.

   The way we solved this problem: ______________________________

2. On September 4, 1981, a tornado hit Ancona, Italy. It lifted a baby sleeping in its crib 50 feet in the air and carried it 328 feet away. The baby was set down safely and remained asleep throughout the whole ordeal.

   Work with your group of four to determine where you would be if you were carried 328 feet from the door of your classroom.

   We decided we would be: ______________________________

   The way we solved this problem: ______________________________

SPEED LIMIT 200

Grading Matrix

Names ____

Date ____________________ Class ____________________

Criteria	4	3	2	1
Accuracy of computation				
Quality of written responses				
Overall quality of project and group cooperation				
Comments:				

Additional Reading

Adoff, A. 1977. *Tornado! Poems.* New York: Delacarta Press.

A poetic description of a tornado and its aftermath.

Bethancourt, T. E. 1984. *The tomorrow connection.* New York: Holiday House.

In 1906, two musicians find themselves stranded. What do they do? They ask Harry Houdini to help them find the gate to the future. As they travel across the country, they arrive in San Francisco just in time for the great earthquake.

Billout, G. 1981. *Thunderbolt and rainbow: A look at Greek mythology.* Englewood Cliffs, N. J.: Prentice Hall.

This book examines the many myths and legends surrounding natural phenomena such as hurricanes, volcanoes, etc.

Bottner. B. 1995. *Hurricane music.* New York: Putnam.

After Aunt Margaret finds an old clarinet in her basement, her life changes. She develops a musical lifestyle that includes "jamming with hurricanes."

Cottonwood, J. 1995. *Quake.* New York: Scholastic.

Fourteen-year-old Franny is alone with her younger brother and cousin in her home on Loma Prieta Mountain, California, when an earthquake destroys it. This story tells how they cope with fear and danger.

DeSpain, P. 1994. *Eleven turtle tales: Adventure tales from around the world.* Little Rock, Ark.: August House.

A charming book with a collection of folk tales from around the world. One of them, a Native American tale, tells the story of how the great spirit formed California on the back of giant turtles and why there are earthquakes.

Elting, M. 1990. *Volcanoes and earthquakes.* New York: Simon and Schuster Books for Young Readers.

Written for young people, this book tells how earthquakes and volcanic eruptions occur and how they can be predicted.

George, J. C. 1966. *One day in the prairie.* New York: Crowell.

A nonfiction account of how the animals on a prairie wildlife preserve sense an approaching tornado and attempt to protect themselves before it touches down.

Johnson, T. P. 1968. *When nature runs wild.* Mankata, Minn.: Creative Education Press.

What are the causes and effects of violent natural phenomena such as earthquakes, floods, and hurricanes? This book relates the power of nature and suggests experiments and projects for students.

Kudlinski, K. V. 1993. *Earthquake: A story of old San Francisco.* New York: Viking.

In 1906, after the infamous San Francisco earthquake, twelve-year-old Phillip struggles to save the horses in his family's livery stable.

Lowell, S. 1993. *I am Lavina Cumming.* Minneapolis, Minn.: Milkweed Editions.

The death of ten-year-old Lavina's mother makes it necessary for her to stay with relatives in San Francisco. Her adventures include living through the great earthquake.

Milton, H. H. 1983. *Tornado!* New York: F. Watts.

Fourteen-year-old Paul is faced with incredible problems when he is stranded with his mother and younger sister after a tornado and flood. A story of heroism and intelligence.

Simon, S. 1981. *Einstein Anderson makes up for lost time.* New York: Viking Press

Einstein Anderson, a science sleuth, uses his scientific knowledge to solve a variety of puzzles, including inventing a machine that can stop hurricanes.

Skurzynski, G. 1984. *Caught in the moving mountains.* New York: Lothrop, Lee & Shepard Books.

Two thirteen-year-old boys have the adventure of a lifetime while they are hiking in the mountains as an earthquake strikes the area.

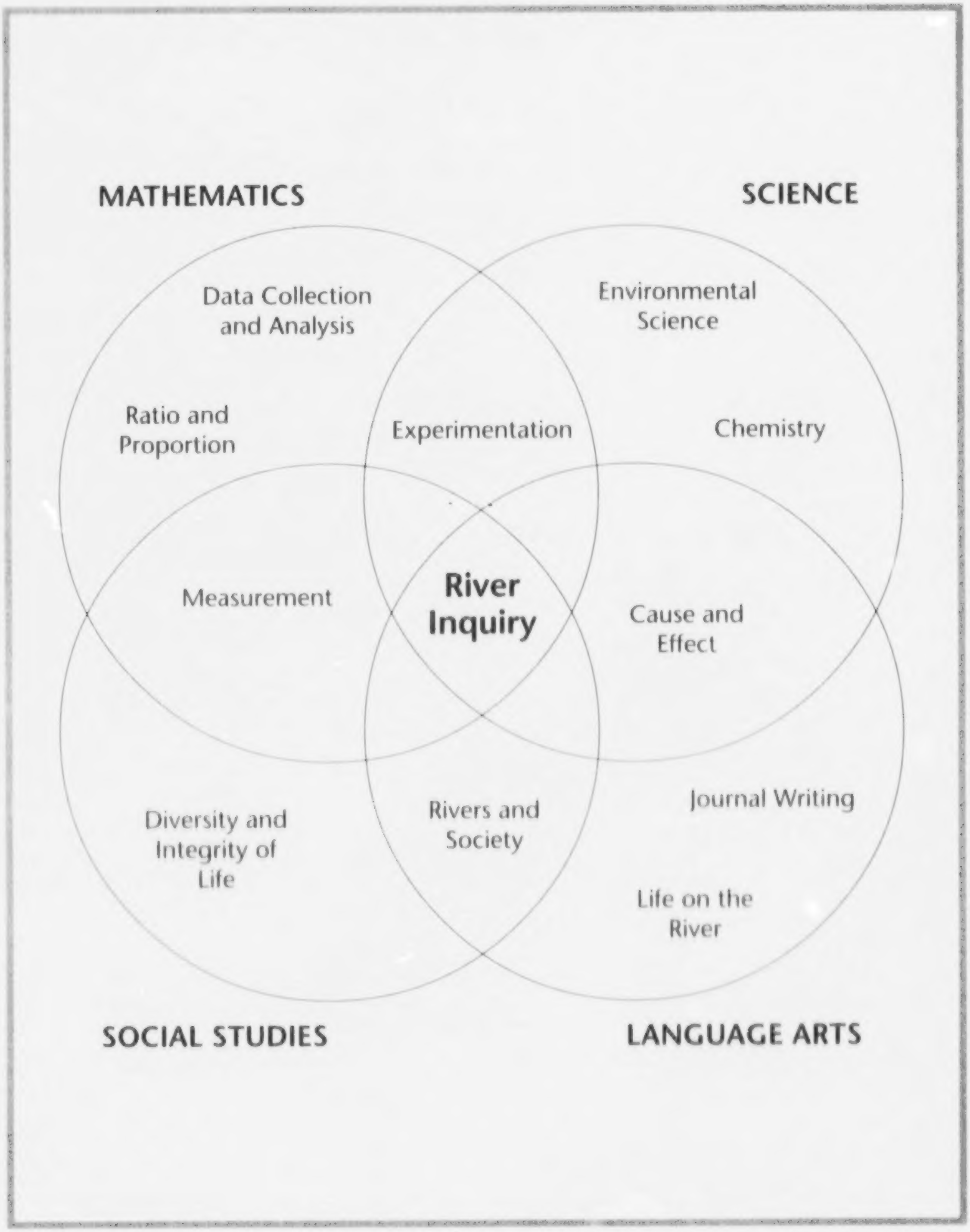
Winthrop, E. 1984. *Belinda's hurricane.* New York: Dutton.

This book tells the adventures of Belinda and her grandmother as they wait out a hurricane on Fox Island.

CHAPTER 2

Local River Inquiry

Interdisciplinary Unit


MATHEMATICS
SCIENCE
Data Collection and Analysis
Environmental Science
Ratio and Proportion
Experimentation
Chemistry
Measurement
River Inquiry
Cause and Effect
Diversity and Integrity of Life
Rivers and Society
Journal Writing
Life on the River
SOCIAL STUDIES
LANGUAGE ARTS

CHAPTER 2

Local River Inquiry

Interdisciplinary Unit

This unique interdisciplinary unit examines the historical significance, environmental concerns, water quality, and characteristics of a local river system. This unit permits students to study a narrow and minor reach of a large river both mathematically and scientifically. It ties the life of a river to the towns and cities around it.

Although about 70 percent of the earth's surface is covered by water, only 3 percent of it is fresh water; the rest is salty. Of that 3 percent, 2 percent is at the poles and is frozen in ice sheets and glaciers. Only about 1 percent of the fresh water is found in rivers, lakes, and underground streams. Our fresh water is a precious commodity and needs to be treasured and protected.

The social studies component investigates the human and geographical history of the system and its impact on the growth of the region. The science component examines the interrelationship between regional growth and the aquatic ecology of the system. Mathematics is used as a tool to calculate the size, rate of flow, and seasonal levels of the river, as well as to assess its health. The language arts/literature component introduces students to the river experiences of others and gives students the opportunity to share their own experiences through their writing.

Outside resources can include boat trips on the local river and visits from local historians who can relate the history of the region. Many groups dedicated to saving the earth's rivers work with schools to help them expand their ecology programs. Local health departments also have outreach departments designed to work with schools to teach students how to protect the rivers, lakes, and oceans of our planet. These experts can be of invaluable help in the planning and implementation of a project of this magnitude.

Nontraditional curricular models need to have available alternatives to traditional assessment models. When appropriate, suggestions are made for the assessment of students.

CONCEPTS

Science

- Experimentation
- Chemistry—Quantitative and qualitative analysis
- Biology—Identification of organisms and the environment they live in
- Data collection and analysis
- Cause and effect
- Environmental science
- Assessment of the health of the river (connections between science, social studies, and mathematics)

Student-conducted science experiments determine the quality of the water. Students can examine the types of macroinvertebrates in the river, test the acidity or alkalinity of the water using pH paper, and measure the amount of dissolved oxygen in the water at the river. By taking samples of the water and bringing them back to the science lab in glass bottles, students can measure the nitrate and phosphate concentration of the water to see the effects of fertilizer run-off and detergents. Chemical water-testing kits are available at a reasonable price from large chemical supply houses.

Social Studies

- Local geography
- The interconnection between the history of regions and their river systems

- Hydrographic basin—The study of water and how it drains
- Connections between social studies, mathematics, and science
- Using geography tools (maps, compasses, measuring tapes, etc.)
- Appreciation for the diversity and integrity of life
- Taking stewardship of our local rivers

Throughout history, societies have developed near rivers that could be used for transportation, human consumption, and irrigation. Some interesting questions to explore:

1. How have the rivers in your area influenced your history? Is the history of your area closely tied to the history of the river?
2. What connections are there between the health of the rivers and bodies of water and the health of our planet?
3. Have there been efforts to improve the quality of the river in your area? Was it, or is it still, polluted? How can your students help protect and take stewardship of your local reach?
4. Where are local storm drains? They should be identified so they are not used for disposal of toxic substances.

As part of the study of world geography, the mighty rivers of the world can be examined along with the cities that grew up along their shores. This table gives some of their statistics:

River	Country	Length
Yangtze	China	5,520 km
Mississippi/Missouri	United States	6,020 km
Amazon	Brazil	6,437 km
Nile	Egypt	6,670 km

Other great rivers are the Volga and Rhine in Europe and the Murray and Darling in Australia.

Language Arts/Literature

- Reading and writing in context
- An examination of the importance of rivers in different cultures through stories, poems, and fables
- Rivers as an important setting in literature
- Journal writing in science
- Observation writing in language arts
- Personification of nature

Using reading and writing in the content areas allows us to expand on, enhance, and develop science, social studies, and math concepts for projects. Many stories and books describe great rivers or focus on the people who live and depend on rivers.

Examples of literature to enhance this project include *Pages from a Rio Grande Notebook* by Paul Horgan; *Cross over the River* by Sam Cornish; *The Stream* by Lula Lowe Weeden; *The Negro Speaks of Rivers* by Langston Hughes; *The River* by Dabney Stuart; *Song of the Brook* by Lord Alfred Tennyson; *How Thunder and Earthquake Made Ocean,* a Yurok Indian Myth; and *The Good River* by Pearl Buck. Optional literature can include Mark Twain's *Cub Pilot on the Mississippi* and *Tom Sawyer.* Issues involving civic responsibility toward the river are addressed in *A River Ran Wild* by Lynne Cherry.

Students can be required to keep a journal of the activities and their experiences during this project. An appropriate form has been supplied and it can be kept with data collection and other worksheets in a student's folder. A final assessment component should include the quality of the student's journal as a chronicle of the river experience.

Mathematics

- Measurement (linear, angle, and time)
- Use of formulas and constants
- Ratio and proportion (tangent, grade, and speed of current)

My Journal for the River Project

- Connections between mathematics, social studies, and science
- Data collection and analysis (including graphing)

Mathematically, students will measure and approximate the speed, the distance across, and the depth of the river in order to compute its rate of flow. Also, by measuring the temperature at various times, students can determine the range of temperatures that will support the life of the river.

UNIT OVERVIEW

The speed of the river will be determined by conducting the experiment detailed on the "Speed of the River" blackline. Using a variation of the distance formula, students will measure the time it takes for an orange to travel a distance of thirty meters and compute the rate it traveled. Students will use the scientific method and conduct the trial three times and take an average.

"How Far across the River?" is a lesson developed to approximate the distance across a river when it cannot be measured using standard measurement techniques. Of course, if a tape measure or other standard method could be used, it would not be necessary to go to these extremes! But, how does one measure a distance that is too big to be measured? This lesson uses orienteering compasses, metric tapes, and trigonometric ratios to find a distance when one side and one angle of a right triangle is known. A prerequisite for this activity is knowing how to use an orienteering compass. Some excellent materials are available through Silva Orienteering.

To find the depth of the river, students use weighted, knotted ropes to take measurements in three locations across the river (it's helpful if there is a bridge for students to use) and compute the average.

The rate of flow is a calculation of the volume of water that flows through a particular region in a measured amount of time. Its label, meters/second, indicates that it is dependent on the speed as well as the volume of water in that area. Once students have computed the distance across, the depth, and the rate (or speed) of the river, they are ready to calculate the rate of flow.

Additional monitoring will involve temperature readings. These readings should be taken at varied times to see if the quantity of macroinvertebrates and the chemistry of the water changes with the change in temperature. In areas with seasonal weather changes, it is interesting to note the range of temperature changes throughout the year.

While this interdisciplinary unit contains fundamental components of all of the major disciplines in middle school, it weaves isolated skills and knowledge into an integrated whole for students. It makes "real-world" connections between science, social studies, literature, language arts, and mathematics.

Rate of the River

MATHEMATICAL CONNECTIONS

measurement (time), use of distance formula, averages

INTELLIGENCES

bodily/kinesthetic, interpersonal, logical/mathematical, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Scientific inquiry, experimentation

Social Studies: Local geography, hydrographics

Language Arts: Journal writing

CONCEPTS

Students will do the following:

1. Use a stopwatch to accurately record time to the nearest $^1/_{10}$ second
2. Find rate when time and distance is known
3. Find the average rate of speed after three trials

MATERIALS NEEDED

stopwatches; copies of the "Computing the Rate of Flow" blacklines for each group; one clipboard per group of four; oranges or lemons (for an ecologically safe instrument)

PROCEDURES

Before students conduct the experiment at the river, a distance of thirty meters needs to be measured off. Students will place oranges or lemons in the water at one endpoint and time how long it takes for them to cross the second endpoint. In this way, the distance is constant in the formula.

Discuss with students:

1. The distance formula: (Distance = rate x time). If we know the distance (30 meters) and the time (to be determined with the stopwatch), how can we calculate the rate?
2. Why oranges and lemons are used for the experiment rather than rubber balls.
3. Why three measurements will be taken and averaged. (The average of three measurements is much more accurate than one single measurement.)

Examine the available stopwatches. PE departments usually have some they will share for a short period of time. Most good stopwatches measure to the nearest $^1/_{100}$ of a second, and students need to practice with them and learn to round to the nearest $^1/_{10}$ of a second. After the measurements are taken, students will need practice finding the average.

Place students into groups of four: One student will drop the orange in the river at one endpoint and shout "Start!"; the second student will carry the clipboard and record the data; the third student will carefully watch the orange until it just crosses the thirty-meter mark; and the fourth student will keep the stopwatch. Practice is needed to coordinate the timekeeper with the orange droppers and stoppers.

Large nets can be used to retrieve the oranges—but if you lose some—not a big deal. Some little critter should enjoy the fruit!

ASSESSMENT

1. Observation of students during data collection
2. Quality of data collected
3. Journal question: "Explain the distance formula and how your group used it to find the speed (or rate) of the river."

Speed of the River

Names ____

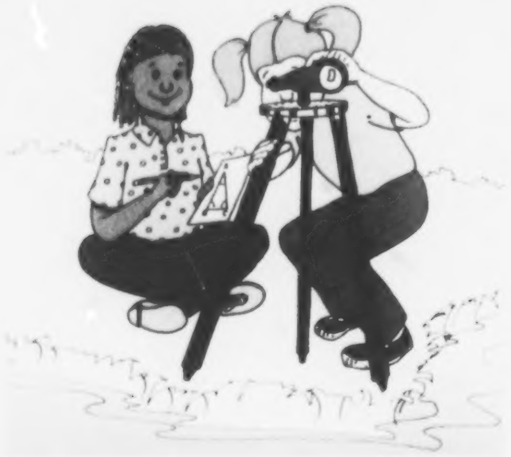
Date ____________________ Class ____________________

Work with your group of four to find the rate or speed at each location. You will assume the following roles:

1. Orange dropper—places the orange in the river
2. Orange recorder—carries the clipboard and records the trials
3. Orange stopper—keeps sight of the orange in the water and notifies the timer when it reaches its destination
4. Orange timer—uses the stopwatch to determine the time

Your rate of flow will be computed by taking the distance the orange travels and dividing it by the time it takes.

Trial #	**Distance** (d)	**Time** (t) *(in tenths of a second)*	**Rate** $\frac{d}{t}$
1	30m		
2	30m		
3	30m		
AVERAGE			



How Far across the River?

MATHEMATICAL CONNECTIONS

measurement, ratio and proportion, problem solving, tangents

INTELLIGENCES

bodily/kinesthetic, interpersonal, logical/mathematical, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Measurement, scientific inquiry

Social Studies: Use of directional compasses, geography

Language Arts: Journal writing, literature

CONCEPTS

Students will do the following:

1. Use compasses to sight angles (relative to north)
2. Measure the distance between two points
3. Compute the distance across the river using trigonometry ratios
4. Round distances to the nearest centimeter

MATERIALS NEEDED

compasses; meter tapes or meter sticks; clipboards

PROCEDURES

Once students understand how to use compasses to sight objects at a particular angle, they will use them and the tangent ratio to find the distance across the river using the techniques outlined in this activity. It is important to review the procedures with them in class before they go on site.

Prior to student measurements, two points should be staked out on both sides of the river; these points should be at right angles to each other. North and south represent 0° and 180°, respectively. When students sight from point A to point B, they are determining the angle measurement from north. If the river flows from north to south, this first measurement may not be necessary. Otherwise, the angle across the river is equal to the difference between the two sightings.

Using the stakes provided and working in groups of four, students will measure the following:

1. The sight angle of bearing from point A to point B
2. The distance between points A and B
3. The sight angle of bearing between point B and the point on the tree (T) across the river

ASSESSMENT

1. Observation of student groups
2. Journal question: "Explain how you used the tangent ratios to find the distance across the river."

Using Tangent Ratios

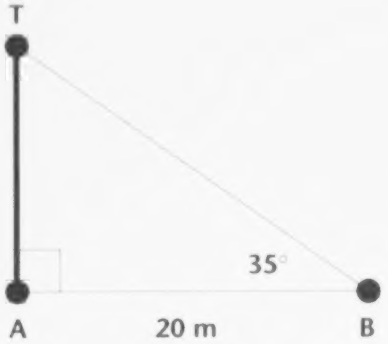
Names ______________________

____

Date ______________________

Class ______________________

We can use mathematics to help us figure out how far it is across a river. Right triangles have special attributes that can help us find the length of an unknown line. Let's examine this diagram:



You are standing at point B and sight a tree that is at a 35° angle across a river (T). Someone in your group places a pole at a 90° angle from that same tree (A). We also know that the distance from A to B is 20 meters. We have all the information that we need to find the distance from point A to the tree without crossing the river. Using the tangent ratio:

$$\text{tangent } 35^\circ = \frac{AT}{20\text{m}}$$

Substitute the value for the tangent of 35° into the equation and you will find that the distance across the river is about 14 meters.

$$0.7002 = \frac{AT}{20\text{m}}$$

$$0.7002(20) = AT$$

$$14.004 = AT$$

Values for the Tangent of an Angle

Angle	tan
0°	0.000
1°	0.0175
2°	0.0349
3°	0.0524
4°	0.0699
5°	0.0875
6°	0.1051
7°	0.1228
8°	0.1405
9°	0.1584
10°	0.1763
11°	0.1944
12°	0.2126
13°	0.2309
14°	0.2493
15°	0.2679
16°	0.2867
17°	0.3057
18°	0.3249
19°	0.3443
20°	0.3640
21°	0.3839
22°	0.4040

Angle	tan
23°	0.4245
24°	0.4452
25°	0.4663
26°	0.4877
27°	0.5095
28°	0.5317
29°	0.5543
30°	0.5774
31°	0.6099
32°	0.6249
33°	0.6494
34°	0.6745
35°	0.7002
36°	0.7265
37°	0.7536
38°	0.7813
39°	0.8098
40°	0.8391
41°	0.8393
42°	0.9004
43°	0.9325
44°	0.9657
45°	1.0000

Angle	tan
46°	1.0355
47°	1.0724
48°	1.1106
49°	1.1504
50°	1.1918
51°	1.2349
52°	1.2799
53°	1.3270
54°	1.3764
55°	1.4281
56°	1.4826
57°	1.5399
58°	1.6003
59°	1.6643
60°	1.7321
61°	1.8040
62°	1.8807
63°	1.9626
64°	2.0503
65°	2.1445
66°	2.2460
67°	2.3559
68°	2.4751

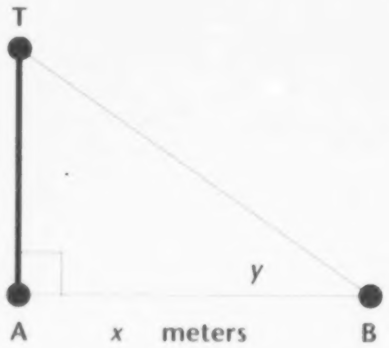
Angle	tan
69°	2.6051
70°	2.7475
71°	2.9042
72°	3.0777
73°	3.2709
74°	3.4874
75°	3.7321
76°	4.0108
77°	4.3315
78°	4.7046
79°	5.1446
80°	5.6713
81°	6.3138
82°	7.1154
83°	8.1443
84°	9.5144
85°	11.4301
86°	14.3007
87°	19.0811
88°	28.6363
89°	57.2900
90°	∞

Collecting Data

Names ____________________

Date ____________________

Class ____________________



Working in your group of four, do the following:

1. Measure distance x, the distance from A to B.
2. Using your compass and standing at point B, sight the angle of bearing from point B to point A.
3. Now from point B, sight the angle of bearing from point B to point T.
4. The angle at B, y, is the difference between these two bearings.
5. Enter your data (measurements) on the table below.

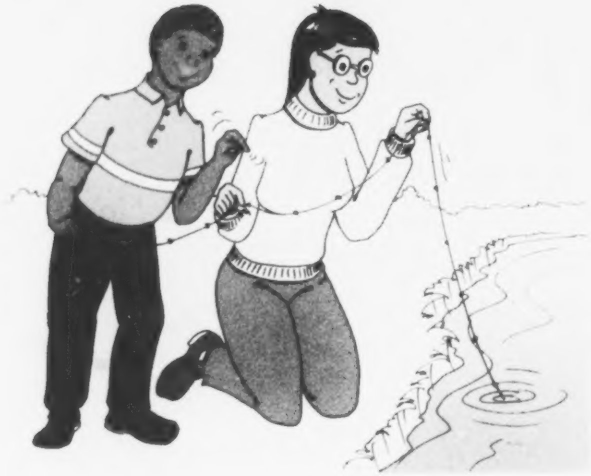
Measurement	Trial 1	Trial 2	Trial 3	Average
Distance from point A to point B				
Sighting from point A to point B (in degrees)				
Sighting from point B to point T (in degrees)				
Difference between two sightings (in degrees)				

The average difference in the two bearings is: ____________________

Use the values on the Tangent Table and your measurements to compute the distance across the river.

$$\text{Tangent} < y = \frac{\text{distance across the river (unknown)}}{\text{length of AB}}$$

The distance across the river is ____________________



Depth of the River

MATHEMATICAL CONNECTIONS

measurement (linear), data collection, averaging

INTELLIGENCES

bodily/kinesthetic, interpersonal, logical/mathematical, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Measurement, scientific inquiry

Social Studies: Geography

Language Arts: Journal writing

CONCEPTS

Students will do the following:

1. Use nontraditional methods to find the depth of a river
2. Find the average of three different measurements in order to find the mean depth
3. Work with metric measurements

MATERIALS NEEDED

rope knotted at 10 dm distances; clipboards

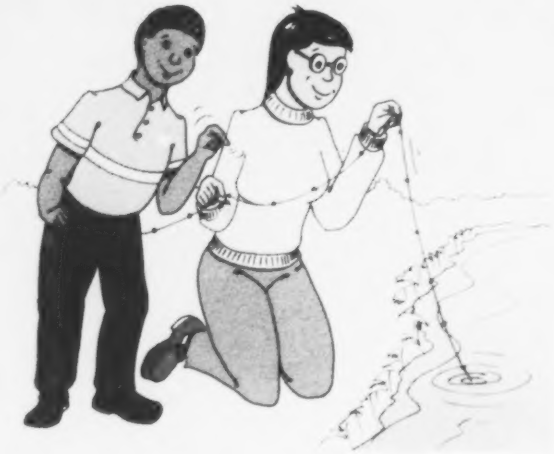
PROCEDURES

Before taking measurements at the river, it is necessary to knot a rope at 10 dm intervals and tie a weight at the end so it will sink below the surface of the water. When planning a sight for this experiment, it is imperative for students to use a bridge so measurements can be taken in the middle and along the two banks. If this is not possible, your team must problem solve an alternative procedure. You might wish to change the data collection sheet to reflect the changes.

Place students into groups of four: One member will record the data; the second and third members will observe at the water's edge; and the fourth member will be responsible for the rope. If the knots are color coded, observation of depth is easier to make. For example, the depth can be recorded as being between the red and green marks. Later, accurate measurements can be made on the rope.

ASSESSMENT

1. Observation of students
2. Accuracy of data collection
3. Journal question: "Why was it necessary to take three measurements at various places across the river? Why didn't these varied distances make our data inaccurate?"



Measuring

Names ______________________

____

____

Date ______________________

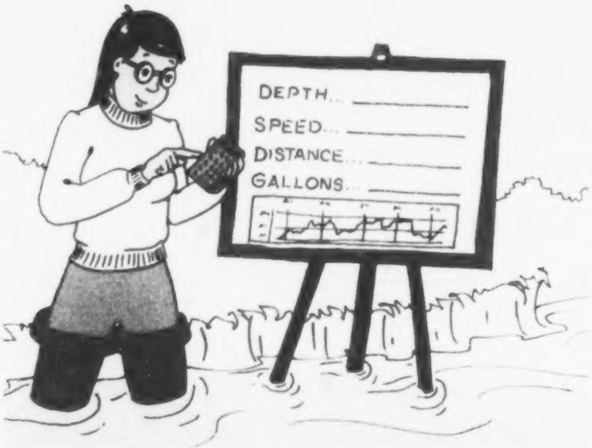
Class ______________________

From your other experiments, you know the following:

1. The width of the river (the distance across)
2. The speed of the river

Now we will find the depth of the river. Using a knotted rope with an attached weight—or using meter sticks—take measurements at three different locations. Then, enter the data on the table below and find the average depth.

Location	**Depth**
1	
2	
3	
Average	


DEPTH...
SPEED...
DISTANCE...
GALLONS...

Rate of Flow of the River

MATHEMATICAL CONNECTIONS

computation, using formulas

INTELLIGENCES

logical/mathematical, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Physics, scientific inquiry

Social Studies: Geography, hydrographics

Language Arts: Journal writing

CONCEPTS

Students will do the following:

1. Utilize previous data to find the rate of flow of the river
2. Substitute calculated measurements into a formula

MATERIALS NEEDED

data from previous experiments; calculators

PROCEDURES

This activity is done after other experiments and measurements have been completed. The activity is done in the classroom. If students are not in class with the same students that were in their group, you might want to make copies of the group data so that each student will have a copy of his or her own data. Otherwise, all of the data can be placed in a spreadsheet and computed for the class as a whole.

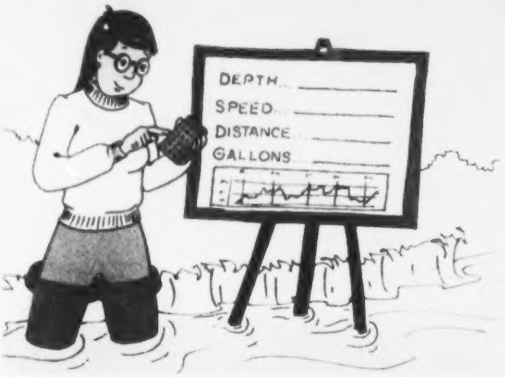
The rate of flow is the time it take for a given amount of water to pass through a point. This necessitates knowing the volume of water and the time it takes for that volume to pass through a point. Look at the formula:

Rate of Flow =
Width (in meters) x Depth (in meters) x Speed $\left(\frac{\text{meters}}{\text{second}}\right)$

By using all of the labels, we see that we have m^3/sec, the label used to describe this data.

ASSESSMENT

1. Accuracy of calculations
2. Journal question: "Explain how the rate of flow differs from the rate or speed of the river."



Computing the River's Rate of Flow at a Particular Point

Names ____________________

Date ____________________ Class ____________________

The average width of the river (distance across) is ____________________

The average speed of the river (rate) is ____________________

The average depth of the river is ____________________

We will use these three statistics to find the rate of flow of the river at a particular point.

***Rate of Flow* is the cubic meters per second at which a river flows.**

$$\text{Rate of Flow} = \text{width (in meters)} \times \text{depth (in meters)} \times \text{rate} \left(\frac{\text{m}}{\text{sec}}\right)$$

Use this formula to make your computations in the space provided below:

Temperature of the River

MATHEMATICAL CONNECTIONS

measurement (temperature), data collection and analysis, graphic representation

INTELLIGENCES

bodily/kinesthetic, interpersonal, logical/mathematical, verbal/linguistic, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Measurement, scientific inquiry

Social Studies: Geography, hydrographics

Language Arts: Journals

CONCEPTS

Students will do the following:

1. Take the temperature of the river and record data over a period of time
2. Analyze the data with regard to the quality of the river

MATERIALS NEEDED

thermometers (Celsius); clipboards

PROCEDURES

Discuss with students the possible range in water temperature. Is it possible for the temperature to fall below 0° C? Why or why not? Depending on weather conditions in your area, there could be large variations in water temperature.

When temperature is taken, some water samples should be collected and analyzed in the lab for changes in macroinvertebrates and plant life. The temperature can be taken by one group of four every two to three weeks and reported to the entire class.

The graph of temperatures can be a broken-line graph.

ASSESSMENT

1. Observation of students
2. Quality of data collection and graph
3. Journal Question: "Why is it necessary to record the water temperature at frequent intervals of time?" "What changes did you find in the plant and macroinvertebrate life?"

Taking the River's Temperature

Names ______________________

____

Date ______________________

Class ______________________

Using Celsius thermometers, determine the water temperature and record the date and the time of day it was taken on the table below. Be sure to indicate at which site your measurements were taken.

Site:		
Month/Day/Year	**Time of Day**	**Temperature**

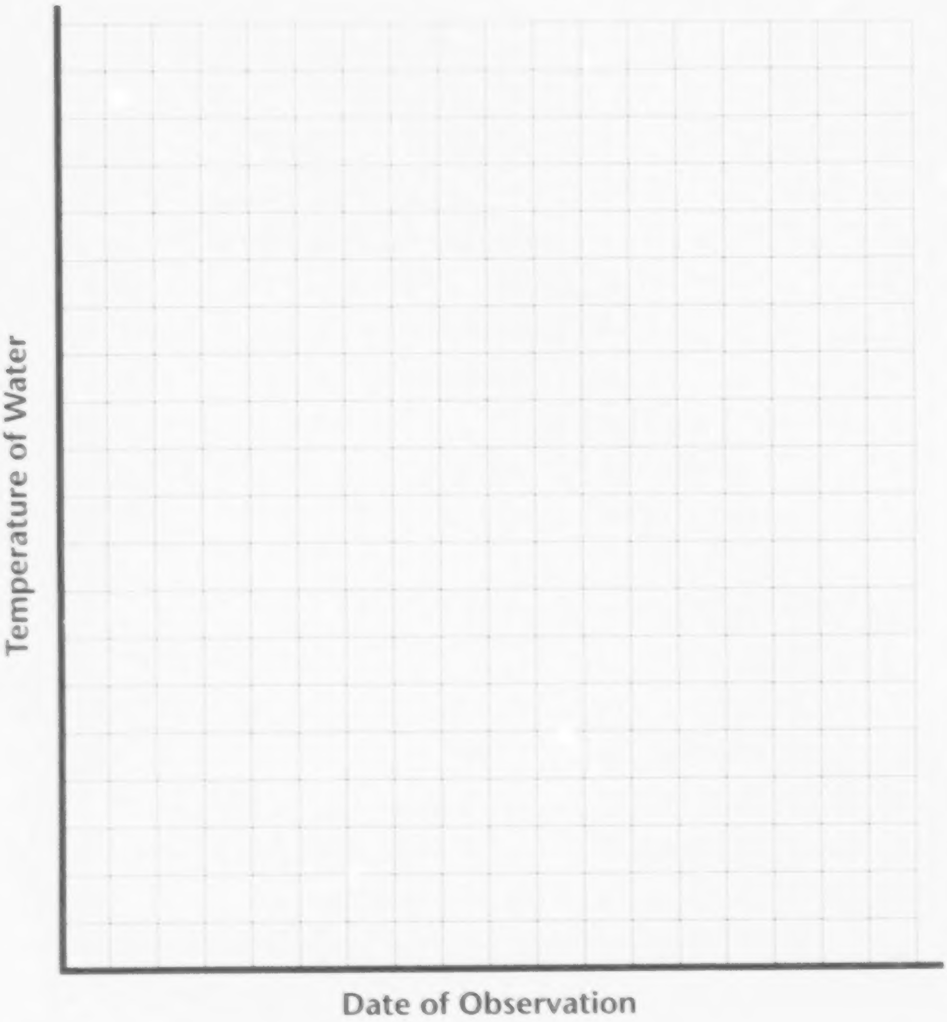
Graphing the Data

Names ______________________

____

Date ______________________

Class ______________________



Additional Reading

Anderson, L. 1971. *Abe Lincoln and the river robbers.* Champaign, Ill.: Garrard Publishing.

The adventures of nineteen-year-old Abe Lincoln and his friend Allen Gentry on a flatboat journey down the Ohio and Mississippi rivers.

Browne, T. 1982. *Rivers and people.* Morristown, N. J.: Silver Burdett Co.

A nonfiction book that tells the story of rivers and stream ecology.

Dorros, A. 1991. *Follow the water from brook to ocean.* New York: HarperCollins.

Explains how water flows from brooks to streams to rivers and eventually reaches the ocean.

Kherdian, D. 1981. *Beyond two rivers.* New York: Greenwillow Books.

Ted and Joe return to McCable River on a camping trip hoping to contact a hermit living in a nearby cave.

McCauley, J. R. 1988. *Let's explore a river.* Washington, D. C.: National Geographic Society.

Three children accompany their father in a canoe to explore the plant and animal life along a river near their home.

Morgan, N. 1994. *The Mississippi.* Austin, Tex.: Raintree Steck-Vaughn.

An overview of the Mississippi River, its physical features, plants and wildlife, history, and future.

Rowland-Entwistle, T. 1987. *Rivers and lakes.* Morristown, N. J.: Silver Burdett Co.

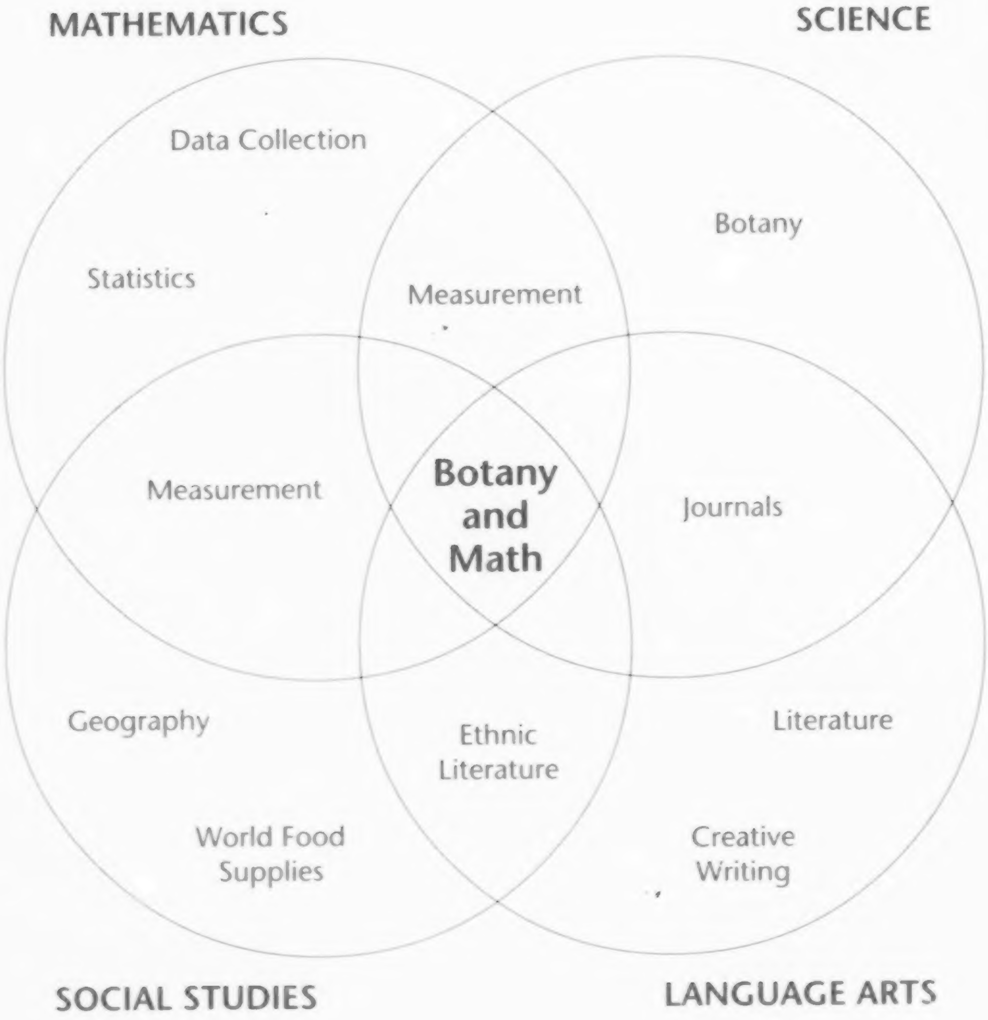
Discusses the kinds of rivers, the cycle of water, how rivers wear away at the land, life in rivers (from snails to trout), the animals that live in and around rivers, and how and why towns grew up around rivers and lakes.

Sanders, S. R. 1995. *The floating house.* New York: Bradbury Press.

In 1815, the McClures sail their flatboat from Pittsburgh down the Ohio River and settle in what is now known as Indiana.

CHAPTER 3

Botany and Mathematics


MATHEMATICS
SCIENCE
Data Collection
Statistics
Botany
Measurement
Measurement
Botany and Math
Journals
Geography
Ethnic Literature
Literature
World Food Supplies
Creative Writing
SOCIAL STUDIES
LANGUAGE ARTS

CHAPTER 3

Botany and Mathematics

> *For many parts of nature can neither be invented with sufficient subtlety, nor demonstrated with sufficient perspicuity, nor accommodated unto use with sufficient dexterity without the aid and intervention of mathematics.*
>
> —Galileo Galilei

The next time you look at a bouquet of roses, take a good look at each of the plants. At first, they all appear to be the same, but upon closer examination, each of the flowers is a unique example of its genus. It's with this philosophy that we embark on the integration of mathematics and science through the study of Wisconsin's Fast Plants.

Wisconsin's Fast Plants, originally developed to study plant diseases, are a remarkable specimen of *Brassica rapa* (a type of cabbage). Once planted, they go from germination to seed in about 40 days! They require minimal care (once a system of reservoirs has been set up), and, if kept under light for twenty-four hours each day, develop attractive flowers to captivate any youngster. Additional information about these plants can be obtained by writing to Wisconsin Fast Plants Program, University of Wisconsin-Madison, Department of Plant Pathology, 1630 Linden Dr., Madison, WI 53706.

"Botany and Mathematics" is truly an interdisciplinary project. The plants can be grown in the science room and measurements taken by students at a prescribed time. After about a week, the seeds will begin to germinate and true leaves will begin to form. Careful observations allow students to chronicle the change in the height of their plants, the plant variations (including pigment, colors of flowers, variegation, color of seeds, and hairiness of leaves), the number of leaves and flowers on each plant, the length and color of leaves, and the development of pods and seeds. It is suggested that students grow four plants each for a few reasons: (1) for statistical analysis (extremes of growth are averaged into the mean); and (2) to allow room for error should some students' plants die. Data collection sheets have been supplied for recording the information.

Throughout the project, students keep a diary or journal. These journals can be written in any class, but it seems appropriate that they be kept in the language arts class.

In the mathematics class, students do the number crunching and make their statistical analyses. The class data can be placed on a spreadsheet, and means and ranges can be determined for the entire group. A sample of a spreadsheet has been supplied with simple formulas depicting the arithmetic mean. In addition, students can be required to maintain a sketch of one of their plants to scale. By keeping a visual record, students are (1) better able to conceptualize the changes, and (2) able to develop their visual/spatial intelligence in a nontraditional setting. Grids (0.5 cm) are supplied for eight different drawings. Students should begin their drawings when plants sprout their cotyledons (first leaves).

Brassica rapa is a form of cabbage that is an essential part of the diet in Asia. In Korea, a form of this plant is chopped and then buried in the earth with preserving spices to pickle it. Kimchee is the name of this dish, and it can be prepared right in the social studies classroom. Although it is a bit aromatic, it is a fascinating addition to the study of geography and the history of Asia.

Botany is an exciting means to help middle school students make connections between mathematics and other curricular areas while supporting and working to enhance their multiple intelligences. The data collection sheets that follow help students keep track of their data in an organized fashion, and the assessment matrix has been expanded to accommodate this comprehensive experience. So . . . put on those gardening gloves and start doing mathematics, science, social studies, and language arts!

Statistics and Variation

MATHEMATICAL CONNECTIONS

data collection, statistics, scale drawing, measurement

INTELLIGENCES

logical/mathematical, verbal/linguistic, visual/spatial, interpersonal, intrapersonal

OTHER CURRICULAR CONNECTIONS

Science: Botany

Social Studies: Geography and history of Asia

Language Arts: Journal writing

Technology: Spreadsheets and computers

CONCEPTS

Students will do the following:

1. Keep a journal and visual record of the growth of their plants
2. Accurately measure and record the growth of their plants in centimeters

3. Accurately record the variation, number of leaves and flowers, and leaf and pod development of their plants
4. Keep track of the growth of their plants using computer spreadsheets

MATERIALS NEEDED

supply of Fast Plant materials (list available from the University of Wisconsin); blacklines to this section

PROCEDURES

To find out how to order a classroom kit of supplies and materials for this project, contact Wisconsin Fast Plants Program, University of Wisconsin-Madison, Department of Plant Pathology, 1630 Linden Dr., Madison, WI 53706.

Once the set-up is complete, discuss the purpose of the project and give each student a planter, some seeds, and wish them luck and a "green thumb." Actually, if the directions for planting and care are followed, the plant growth is wonderful.

The duration of the project is about forty days; plants go from germination to seedling in this amount of time. Students should accurately observe the change of height, the plant's variation, the number of leaves and flowers, the length and color of the leaves, and the development of pods and seeds.

ASSESSMENT

1. Student products—Successful completion of lesson
2. Observation of students
3. "*Brassica rapa* Evaluation"
4. Journal question: "Describe the changes that occurred during the growth of your plant(s), and the data you found most interesting and why."

Growth Grids

Name ______________________________

Date ______________________________

Class ______________________________

Use these grids to keep a visual record of the growth of one of your plants. Each square is 0.5 cm.

Week 1 **Week 2** **Week 3** **Week 4** **Week 5** **Week 6** **Week 7** **Week 8**

My Journal

Name ____________________________________

Date ____________________________________

Class ____________________________________

Tracking My Plants' Growth

Names ______________________________

____

Date ______________________________

Class ______________________________

Date	Age of Plants	Height in Centimeters			
		Plant 1	Plant 2	Plant 3	Plant 4

Getting a Handle on Variation

Names ______________________________

____

Date ______________________________

Class ______________________________

Variegated: Plant in which various parts may be white and green.

Rosette: Plant that grows very compactly at soil level with its leaves fanning out in a circular cluster.

Hairiness: Take one leaf in same location on each plant and count hairs on outer edge of leaf.

Plant Variations	Plant 1	Plant 2	Plant 3	Plant 4
Yellow-green plants				
Purple pigment				
Tall, elongated plants				
Flower colors (cream, orange)				
Variegated				
Rosette				
Seed colors				
Hairiness of plants				

Leaves and Flowers

Names ______________________________

____

Date ______________________________

Class ______________________________

Day	Number of	Plant 1	Plant 2	Plant 3	Plant 4
7	Leaves				
	Flowers				
8	Leaves				
	Flowers				
9	Leaves				
	Flowers				
10	Leaves				
	Flowers				
11	Leaves				
	Flowers				
12	Leaves				
	Flowers				
13	Leaves				
	Flowers				
14	Leaves				
	Flowers				
15	Leaves				
	Flowers				
16	Leaves				
	Flowers				
17	Leaves				
	Flowers				
18	Leaves				
	Flowers				

Length and Color of Leaves

Names ______________________________

____

Date ______________________________

Class ______________________________

Date ______________ Day (age of plant) ______________

Leaf	Length and Color of Leaves			
	Plant 1	Plant 2	Plant 3	Plant 4
Leaf 1				
Leaf 2				
Leaf 3				
Leaf 4				
Leaf 5				

Date ______________ Day (age of plant) ______________

Leaf	Length and Color of Leaves			
	Plant 1	Plant 2	Plant 3	Plant 4
Leaf 1				
Leaf 2				
Leaf 3				
Leaf 4				
Leaf 5				

Length and Color of Leaves (Continued)

Date ______________ Day (age of plant) ______________

Leaf	Length and Color of Leaves			
	Plant 1	Plant 2	Plant 3	Plant 4
Leaf 1				
Leaf 2				
Leaf 3				
Leaf 4				
Leaf 5				

Date ______________ Day (age of plant) ______________

Leaf	Length and Color of Leaves			
	Plant 1	Plant 2	Plant 3	Plant 4
Leaf 1				
Leaf 2				
Leaf 3				
Leaf 4				
Leaf 5				

Observations and/or comments: ______________________________________

Pod Development

Names ______________________________

____

Date ______________________________

Class ______________________________

Directions: Record when pods first appear and how many there are.

Date	Day (age of plant)	Plant 1	Plant 2	Plant 3	Plant 4

Seeds and Pods

Names ______________________

____

Date ______________________

Class ______________________

Plant #	Number of Pods	Number of Seeds	Length of Pods	Other Observations
Plant 1				
Plant 2				
Plant 3				
Plant 4				

Highest number of pods from each plant ______________________

Lowest number of pods from each plant ______________________

Range (difference) ______________________

What is the average number of pods for your plants? ______________________

Graph the results of your computations on the class graph. Compare your results. Explain what factors may have caused your plant to have high, average, or low production. ______________________

____

____

____

____

Plant Growth Spreadsheet

Names ______________________________

____

Date ______________________________

Class ______________________________

This is a sample of the type of spreadsheet students can construct to maintain a record of the development of their plants. Others can be developed in a similar manner using the categories of data being collected. For this spreadsheet, the student would record the number of days of plant growth and the height of each plant on that day. The student could then find the average plant growth by calculating the mean.

	A	B	C	D	E	F
1	Day	Plant 1	Plant 2	Plant 3	Plant 4	Mean
2						$= \frac{(B2+C2+D2+E2)}{4}$
3						$= \frac{(B3+C3+D3+E3)}{4}$
4						$= \frac{(B4+C4+D4+E4)}{4}$
5						$= \frac{(B5+C5+D5+E5)}{4}$
6						$= \frac{(B6+C6+D6+E6)}{4}$
7						$= \frac{(B7+C7+D7+E7)}{4}$
8						$= \frac{(B8+C8+D8+E8)}{4}$

Brassica rapa Evaluation

Names ______________________

____

Date ______________________

Class ______________________

Criteria	5	4	3	2	1
Growth Grids					
My Journal					
Tracking My Plants' Growth					
Getting a Handle on Variation					
Leaves and Flowers					
Length and Color of Leaves					
Pod Development					
Seeds and Pods					
Plant Growth Spreadsheet					

Additional Reading

Blackmore, V. 1984. *Why corn is golden: Stories about plants.* Boston: Little Brown.

Tales and folklore from Mexico including "The Chocolate that Turned to Stone," "Princess Xachiti and the Aloe," and "Why Corn Is Golden."

Brusca, M. C. 1995. *When jaguars ate the moon.* New York: Holt.

A collection of stories about animals and plants of the Americas, including some from Native American folklore.

Holman, F. 1974. *The escape of the giant hogstalk.* New York: Scribner.

The Royal Botanic Garden has had a breakout—the Giant Hogstalk—and it is terrorizing the English countryside. How can it be stopped?

Pellowski, A. 1990. *Hidden stories in plants: Unusual and easy-to-tell stories from around the world, together with creative things to do while telling them.* New York: Macmillan.

A wonderful collection of myths, legends, tales, and folklore about plants, as well as ideas of how to use plants as ornaments, toys, dolls, and musical instruments.

Peterson, S. K. 1990. *Out on a limb: Riddles about trees and plants.* Minneapolis: Lerner Publications.

From the series, *You Must Be Joking,* a collection of riddles about trees and other plants. The collection includes, "What tree has the most bark? A dogwood."

Rey, H. A. 1990. *Elizabite: Adventures of a carnivorous plant.* Hamden, Conn.: Linnet Books.

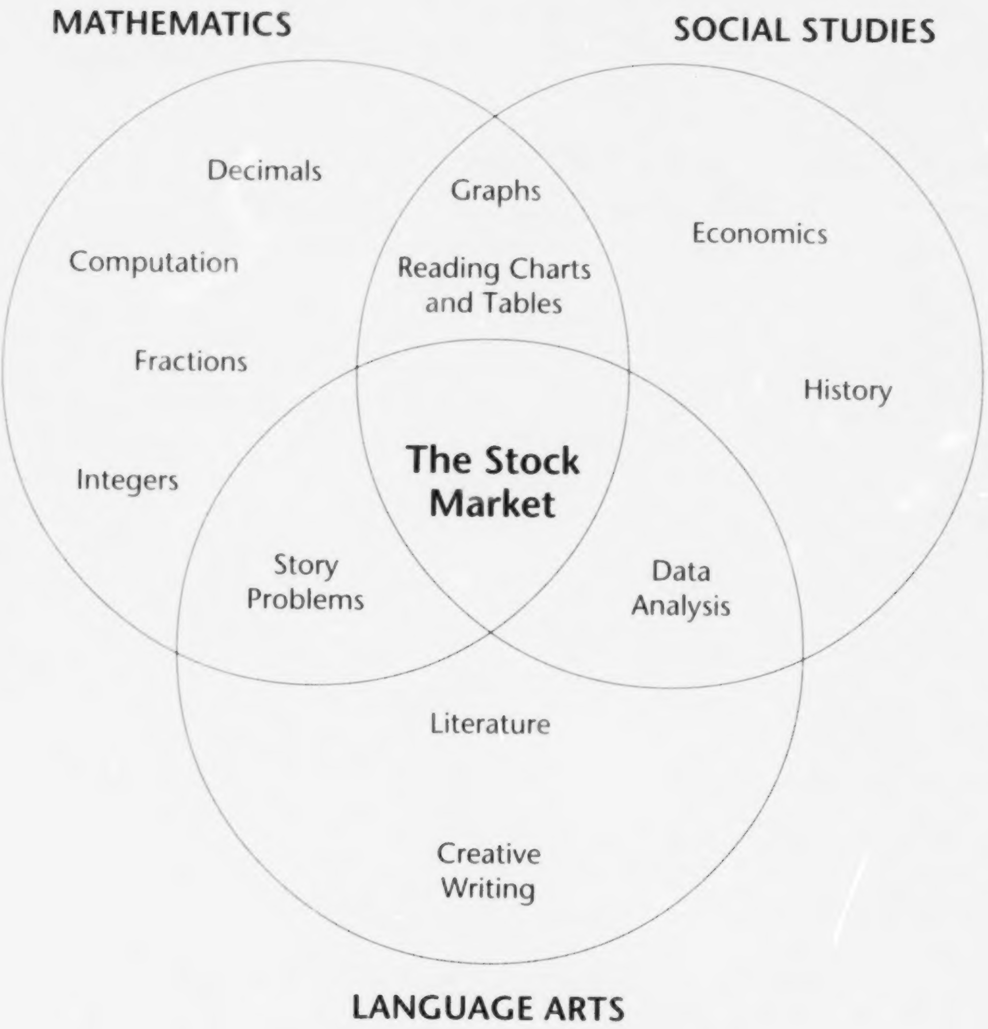
This is a story about Elizabite, an unusual Venus-flytrap plant. Elizabite has the nasty habit of biting anything and everything in sight. She is not a very popular plant until this miserable habit makes her a heroine when she captures a burglar.

Wood, R. 1991. *Science for kids: 39 easy plant biology experiments.* Blue Ridge Summit, Pa.: Tab Books.

From the Science for Kids series, this book presents thirty-nine experiments with plants, including "Why Plants Have Roots," "How a Bean Grows," and "How to Graft a Plant."

CHAPTER 4

The Stock Market


MATHEMATICS
SOCIAL STUDIES
Decimals
Computation
Fractions
Integers
Graphs
Reading Charts and Tables
Economics
History
The Stock Market
Story Problems
Data Analysis
Literature
Creative Writing
LANGUAGE ARTS

CHAPTER 4

The Stock Market

The NCTM's standards maintain that making connections between mathematics and other curricular areas allow students to (1) understand how mathematics relates to their everyday lives; (2) apply mathematical thinking and problem solving to other disciplines; and (3) understand the role mathematics plays in our culture and society. When in the middle grades, students see school mathematics as different from math in the "real world." By connecting math activities to real-world questions, teachers can dispel the notion that school mathematics is useless, and perhaps they will never again have to hear the question, "When are we ever going to use this?"

One area that supports strong interdisciplinary connections is an extended project introducing students to the stock market. The history of the economic growth in the United States shows a country of small, privately owned businesses prior to the 1700s. The industrial revolution brought the growth of businesses, and the need for capital encouraged people to open their businesses to new investment. This was the beginning of public corporations, investments, investors, and the stock market. An examination of the interrelationships between economic growth and history makes a rich study in the social studies classroom.

The stock market crash in 1929 and the literature connected with this black day in American history can make exciting connections between history and literature. Be sure to examine the list of books suggested for additional reading at the end of the project.

In the mathematics classroom, the stock market project is a wealth of essential middle school studies. Conversion of fractions to decimals, computation, percents, graphs, and integers are just a small part of the mathematics students use to keep track of their "investments" during the course of the project.

Investors look to the stock market for long-range investments. A study of the market shows that over the course of one year, investors can make a profit or lose money, depending on the market. When you extend the time frame to five years of investment, you find that during most five-year periods, investors make money in the stock market! This means that as students invest their "money" they should understand the need for patience. Many stock market projects last for too short a period of time. This project has been designed to begin in October and end in May; students keep track of their investments once a week. You will need eight to ten copies of the financial section of the paper for students to use in the stock market project.

Reading the financial section of the newspaper can be very confusing for youngsters, but there is a wealth of information to be found on these pages. The stock market project begins with a short lesson on reading the financial pages and understanding what the column headings mean.

Once students understand the financial pages, they can be asked to research a stock for a period of two weeks. Have them keep track of the closing price each day, graph its ups and downs, calculate how many shares they can purchase with their share of the money, and interview adults to help them make their decisions. When this lesson is completed, the students can contribute their financial knowledge to their groups.

Place students into groups of four and give them $10,000 to invest in four different stocks using the "First Week to Buy Stock" sheet. Each student can make his or her recommendation to the group, purchase the stocks, and enter the costs on the sheet. Each of the stocks should be about 25 percent (or $2,500) of the total. Each student's recommendation should be respected; no one stock should be "loved" more than another! A broken-line graph of the stock's price should be kept each week.

The "Week-to-Week Stock Sheet" is for groups to keep track of stocks once each week. If a group wants to sell a stock, there is a "Planning to Sell" sheet. When the students are prepared to replace the sold stock and buy new stock, there is a "Buying More Stock" sheet. It is a good idea to require groups to keep a stock for at least four weeks, as it is very hectic when a group needs to sell and buy! Finally, at the end of the project, students will sell their stocks using the "Final Sale" sheet. How much are the groups worth? Have they made a profit? Did they invest wisely?

Each phase of the stock market project has an explanation page similar to those supplied with the other interdisciplinary experiences. However, the assessment component is different. The two most significant elements of ongoing assessment for this project are student products (the weekly stock sheets) and the observation of students (the accomplishments of the group). Let's examine each of these individually.

The mathematics involved in this project is difficult for most middle school students. It is essential that their weekly calculations be monitored closely to prevent small errors from becoming monumental inaccuracies. Misconceptions and arithmetic problems can be cleared up quickly if they are controlled weekly.

Observing students is another critical factor of assessment. Each student in the group must be held accountable for the material, especially in such a long-range experience. This is best regulated by careful observation to determine if the following are true:

1. Each student has a viable and important role in the deliberations
2. Each student has a significant task during calculation
3. The roles of students rotate so each has an opportunity to assume a particular role

Because these roles are so different, it is important for them to rotate weekly so each student has the opportunity to learn the skills and concepts that are part of that task.

When setting up the groups, roles can be discussed and the importance of rotation emphasized. The roles of students might be the following:

The recorder—Enters the data from the newspaper

The locator—Finds each of the group's stocks in the paper and determines the closing price

Two computers—Convert the mixed numbers to money (decimals) and complete the Week-to-Week Stock Sheet

A matrix and journal questions have been supplied at the end of the project to complete the holistic assessment.

Some problems may arise as students work together. Following are a few guidelines that may be helpful for the students to know:

1. You are responsible for your own behavior. You must have respect for and consideration of all members of the class. Every group is working hard to keep track of their stocks; they need to be able to concentrate.
2. You must be willing to help anyone in your group who asks. While working in groups, we are interested in co-operation, not competition. Your group cannot succeed financially unless you work together.
3. You may not ask the teacher for help unless all members of your group have the same question. If you have not discussed a question within the group, the teacher will not work with you.
4. Any member of your group may be called on to explain the thinking or reasoning of the group. It is necessary for everyone to understand each part of the project and what the roles involve!

FOREIGN
FUTURES
INDUSTRIALS

Investing in the Market

MATHEMATICAL CONNECTIONS

reading a table, converting fractions to decimals, integers

INTELLIGENCES

verbal/linguistic, logical/mathematical

OTHER CURRICULAR CONNECTIONS

Social Studies: Economics, history

Language Arts: Literature, creative writing

CONCEPTS

Students will do the following:

1. Learn to read information from the financial pages in the newspaper
2. Convert fractions and mixed numbers to decimals
3. Analyze numerical information

MATERIALS NEEDED

calculators; copies of this section's blacklines; local financial papers

PROCEDURES

Discuss with students what a share of stock is. Be sure they understand that if a person owns a share of stock, he or she owns a piece of the company. If any of the students own stock, have them share their investments with the other students. If they don't, ask if they know of a company that they might like to own a piece of.

Read through the "Deciding on a Stock" blackline. The stocks in the table are actual companies and the students should know of them. Most financial pages have additional information to that presented on the table. The data on the "Deciding on a Stock" blackline is all that will be used by groups in their considerations.

Once students understand how to read these pages, give each student a copy of the "Keeping Track of a Stock" blackline so they can track one stock for a period of at least two weeks. It is important to complete this next phase so students understand how to read the financial pages.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students

FOREIGN
FUTURES
INDUSTRIALS
TECHNOLOGY

Deciding on a Stock

Names ____________________________

____

Date ____________________________

Class ____________________________

What is the stock market and why do people invest their money in it? The stock market is a group of companies who sell shares to the public. If you buy a share of stock in McDonalds, you own a piece of that company! How do you know what company to invest your money in? We can learn more about the financial health of a company by understanding the information found on the financial pages of a newspaper.

Below is a table of stock prices for five companies as they appeared in the *Chicago Tribune*. Not all of the columns have been copied, but the ones that have will be used in this lesson.

The first column (52-Week High/Low Stock Prices) is the highest price and the lowest price this stock has sold for in the past 365 days, or previous year. The second column is the name of the company in abbreviated form. Sometimes it is hard to understand the abbreviation. Can you tell what these stand for? The third column is the number of shares of stock that were sold the previous day (3565 means 356,500). The fourth, fifth, and sixth columns indicate, respectively, the highest price anyone paid for the stock this day, the lowest price, and what the stock was selling for when the stock market closed at 3:00 p.m. The Net Change column is not how much the stock changed during the day but how much it has changed from the day before. If the last column shows $+\frac{1}{4}$, the stock cost $.25 more today than when it closed yesterday.

52-Week High/Low Stock 365 Day	Stock	Sales in Hundreds	High	Low	Close	Net Change
$31\frac{3}{8}/22\frac{3}{4}$	AbbtLab	7837	$27\frac{1}{2}$	$27\frac{1}{8}$	$27\frac{1}{2}$	$+\frac{1}{8}$
$61\frac{1}{4}/50\frac{7}{8}$	Amoco	4646	$59\frac{1}{8}$	$58\frac{3}{4}$	59	$+\frac{1}{4}$
$29\frac{1}{4}/16\frac{1}{2}$	CirCty	2067	$23\frac{1}{4}$	$22\frac{1}{2}$	23	$-\frac{1}{8}$
$32\frac{3}{8}/8\frac{1}{4}$	CompUSA	1374	$8\frac{1}{4}$	8	8	$-\frac{1}{4}$
$62\frac{1}{2}/41$	StJoe	83	$59\frac{5}{8}$	$58\frac{3}{4}$	$59\frac{7}{8}$	—

The Dynamics of a Stock

Names ______________________

____

Date ______________________

Class ______________________

Directions: Use the table of stock prices in this packet to answer these questions.

1. Using the 52-week high/low figures, determine the range in prices for each stock:

   a. AbbtLab ______________

   b. Amoco ______________

   c. CirCty ______________

   d. CompUSA ______________

   e. StJoe ______________

2. Which of the stocks showed the greatest fluctuation in price during the day shown? (Remember the Net Change column indicates the change in price from the day before.) ______________

   Explain your answer. ______________________

   ____

   ____

   ____

3. AbbtLab closed at $\$27\frac{1}{2}$, which means that one share cost \$27.50. The equivalent of the fraction $\frac{1}{2}$ is the decimal .50. Convert the high and low prices for the day to dollars and cents (using decimals).

	High	Low
a. AbbtLab		
b. Amoco		
c. CirCty		
d. CompUSA		
e. StJoe		

Keeping Track of a Stock

Name ____________________

Date ____________________

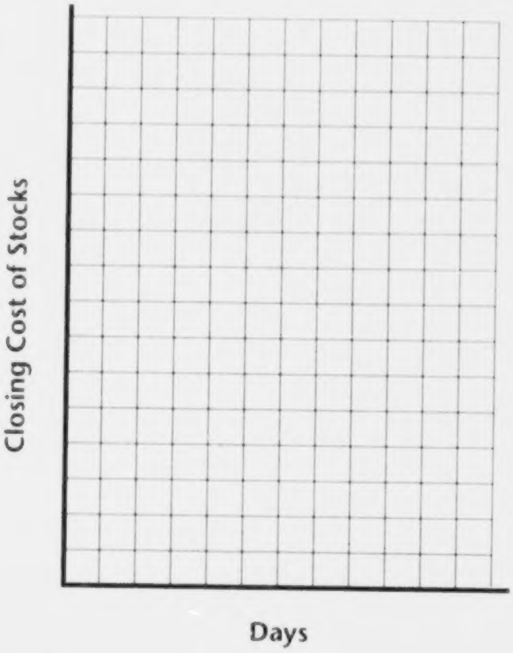
Class ____________________

The stock I will keep track of is ____________________

My reasons for choosing this stock:

1. ____________________
2. ____________________
3. ____________________

A graph of the stock I am keeping track of:



As a result of my research, I will or will not recommend this stock to my group. (Explain what you will do.) ____________________

____

____

First Week to Buy Stock

MATHEMATICAL CONNECTIONS

decimals, percents, mixed numbers, reading information from tables, computation, problem solving

INTELLIGENCES

logical/mathematical, interpersonal

OTHER CURRICULAR CONNECTIONS

Social Studies: Economics, current events

Language Arts: Reading newspapers

CONCEPTS

Students will do the following:

1. Confirm the stock purchases for their groups
2. Determine the number of shares they can purchase of a particular stock for $2,500
3. Calculate the cost of their purchases
4. Balance their checkbooks

MATERIALS NEEDED

calculators (essential); a copy of "First Week to Buy Stock" blackline for each group; a copy of the financial section of the paper that includes closing stock quotations for each group; a file folder for each group

PROCEDURES

Facilitate and assist the groups when questions arise. It is a good idea to allow the groups to solve their own problems. Remember, don't get involved unless everyone in the group has the same problem.

The activity of each stock should be charted on a broken-line graph. A graph sheet ("Closing Stock Prices") follows this segment of the project. The first week there will be only one dot; but, as the students continue to keep track of the stock, a trend will be determined by the direction of the graph.

Give each group a file folder and indicate where they will be stored. At the end of the project, have the students place the data collection sheets in the same folder as the graphs of the stocks.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students

First Week to Buy Stock

Names ______________________________

____

Date ______________________________

Class ______________________________

Use this sheet when your group is buying stock. You will also balance your checkbook by filling out the bottom section.

Name of stock	Abbreviation for stock	Cost per share	Number of shares purchased	Total cost for this stock	This cost is what percent of $10,000?

Total cost of today's purchases ______________________________

Use this section of the sheet to balance your checkbook. By doing this you will have a current record of (1) the amount of money you have invested in stocks, and (2) the amount of money you have not spent (money in the bank).

Balancing the Bank

A. We started with $ ______________________________

B. Subtract today's purchases $ ______________________________

C. Is there any money not spent? $ ______________________________

At the end of this week we have (B + C) $ ______________________________

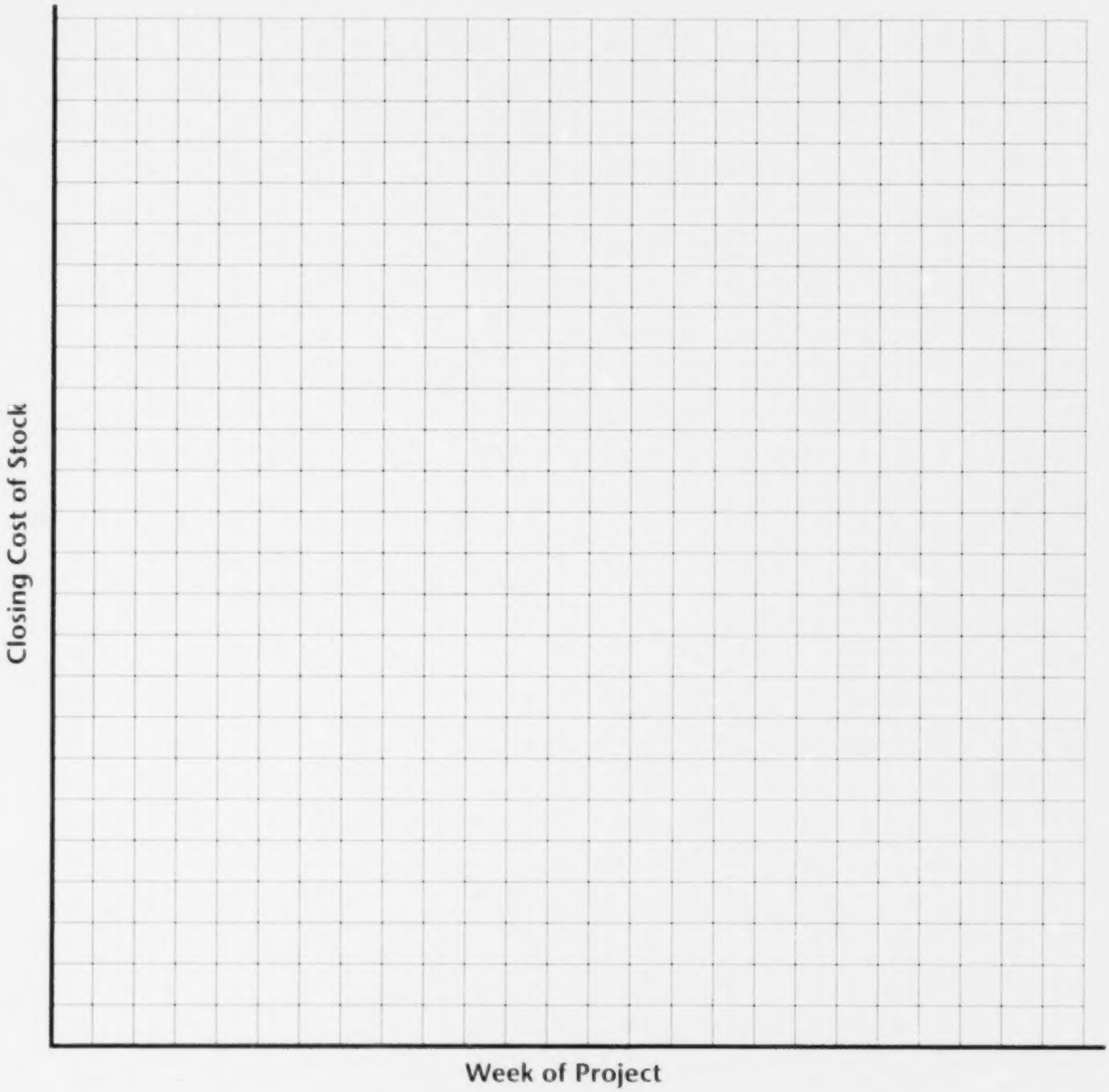
Closing Stock Prices

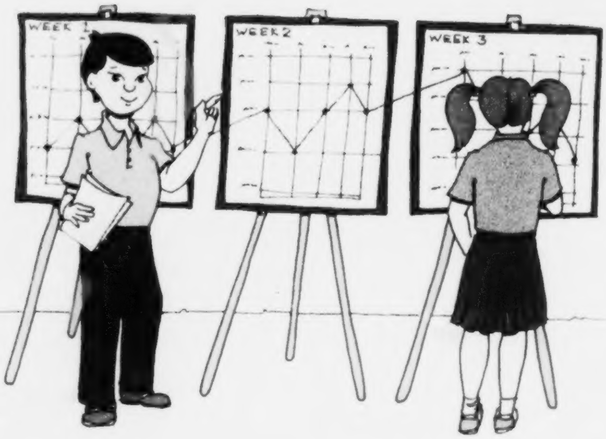
Names ______________________________

____

Date ______________________________

Class ______________________________





Week-to-Week Stock Market

MATHEMATICAL CONNECTIONS

decimals, percents, mixed numbers, reading information from tables, computation, problem solving, integers

INTELLIGENCES

logical/mathematical, interpersonal

OTHER CURRICULAR CONNECTIONS

Social Studies: Economics, current events

Language Arts: Reading newspapers

CONCEPTS

Students will do the following:

1. Record the closing prices of their stocks from the previous week's sheet and find the closing prices of their stocks in the newspaper for the current week
2. Convert the mixed numbers to decimals and record the price
3. Determine if the value of their stock has gone up or down and record this as a positive (+) or a negative (–)

4. Calculate the amount of "profit" or "loss" of each stock
5. Compute if their group has a "profit" or "loss" for the week by finding the sum of the last column
6. Balance the bank by adding (a profit) or subtracting (a loss) from the previous week's value

MATERIALS NEEDED

calculators (essential); a copy of the financial section of the paper that includes closing stock quotations for each group; a copy of the "Week-to-Week Stock Sheet" blackline for each group

PROCEDURES

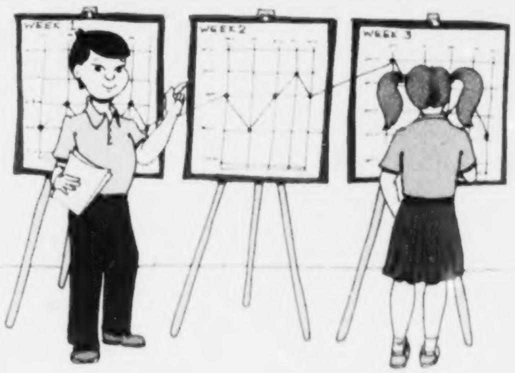
Allow students time to get their stock portfolios (file folders), a copy of the data collection sheet (Week-to-Week Stock Sheet), and a copy of the financial pages. Be sure that groups have rotated jobs or roles.

At this point, your role is facilitator. If a group is really at a loss and no one in the group seems to be able to solve the problem, work with them to resolve the problem. Otherwise, roam around the room, observe the groups' interactions, and note their progress (or lack of progress).

It is best to check the data sheets as often as possible. If time allows, check each group's sheet and initial it as correct.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students



Week-to-Week Stock Sheet

Names ______________________

____

Date ______________________

Class ______________________

Week # ________ Date of newspaper ________________

Use this sheet when your group is keeping track of stocks. You cannot buy or sell stocks using this sheet. Be sure to convert the mixed numbers from the financial column to money (decimals) to make your calculations easier. You will also balance your checkbook by filling out the bottom section.

Abbreviation for stock	Number of shares owned	Closing cost of stock in LAST WEEK'S paper	Closing cost of stock in TODAY'S paper	+ or – (How much?)	Profit (+) or loss (–) multiplied by number of shares

Profit or loss this week (the total of the last column) ______________________

Use this section of the sheet to balance your checkbook. By doing this, you will have a current record of the current value of your stock group.

Balancing the Bank

A. Last week our stocks were worth (see last week) $ ______________________

B. Profit or loss this week $ ______________________

C. This week our group is worth (A ± B) $ ______________________

BROKER
FINANCIAL

Sell Week

MATHEMATICAL CONNECTIONS

fractions, decimals, computation, problem solving

INTELLIGENCES

logical/mathematical, interpersonal

OTHER CURRICULAR CONNECTIONS

Social Studies: Current events, economics

Language Arts: Reading tables, reading nonfiction

CONCEPTS

Students will do the following:

1. Record the closing price of their stock from the previous week's sheet and find the closing prices of their stocks in the newspaper for the current week
2. Convert the mixed numbers to decimals and record the price
3. Determine if the value of their stock has gone up or down and record this as a positive (+) or a negative (–)
4. Calculate the amount of "profit" or "loss" on each stock

5. Compute if their group has a "profit" or "loss" for the week
6. Balance the bank by adding (a profit) or subtracting (a loss) from the previous week's value and adding money received from a sale to the total
7. Sell one of their stocks and record the amount received from the sale

MATERIALS NEEDED

calculators (essential); a copy of the financial section of the paper that includes closing stock quotations for each group; a copy of the "Planning to Sell" blackline for each group

PROCEDURES

If a group of students decides to sell a stock, they must sell it early in the data collection process. Selling stock is time consuming and cannot be rushed. The two most important processes in this transaction are to (1) keep track of the profit or loss for the stocks the group will keep, and (2) find the closing price for the stock to be sold and sell all shares at this price.

The amounts are separated in the stock sheet so that the students will not be confused by the transaction. For example: If a group sells $2,300 worth of stock and has $8,000 remaining in investments, their total worth is $10,300. But, their stock is only worth $8,000! Students will often buy $2,300 worth of stock and consider their total worth as $10,300 + $2,300 instead of $8,000 + $2,300. In other words, they count the money as money and as stock!

It is not wise to allow students to buy and sell during the same week because they tend to work very quickly and are prone to error. They can think about their investments for a week and buy stock the following week using the "Buying Stock Sheet."

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students

Planning to Sell

Names ______________________

____

Date ______________________

Class ______________________

Week # ______________________

Date of Newspaper ______________________

Use this sheet when your group is planning to sell a stock. Keep track of the value of the stocks you are keeping the normal way. Look up their worth in the paper and record your group's profit or loss in the same way you normally would. For the stock you are selling: Do not handle this one in the same way. Enter it on the table below the usual one and keep track only of the amount of money your group has obtained from this sale. Be sure to use the bottom section to keep track of the value of the stock you are selling.

Abbreviation for stock	Number of shares owned	Closing cost of stock in LAST WEEK'S paper	Closing cost of stock in TODAY'S paper	+ or – (How much?)	Profit (+) or loss (–) multipled by number of shares

The profit or loss for the stocks you still own ______________________

Name of stock you are selling	Abbreviation of stock	Today's closing cost per share	Number of shares you are selling	Total money from the sale of this stock

Total money from the sale of today's stock ______________________

A. Last week our stocks were worth ______________________

B. Profit or loss (+ or –) for the stocks we kept ______________________

C. Money we received from the sale of stock today ______________________

D. The value of our group (A ± B + C) ______________________

Buy Week

MATHEMATICAL CONNECTIONS

fractions, decimals, computation, problem solving

INTELLIGENCES

logical/mathematical, interpersonal

OTHER CURRICULAR CONNECTIONS

Social Studies: Current events, economics

Language Arts: Reading tables, reading nonfiction

CONCEPTS

Students will do the following:

1. Record the closing prices of their stocks from the previous week's sheet and find the closing prices of their stocks in the newspaper for the current week
2. Convert the mixed numbers to decimals and record the price
3. Determine if the value of their stock has gone up or down and record the value as a positive (+) or a negative (−)

4. Calculate the amount of "profit" or "loss" on each stock
5. Compute if their group has a "profit" or "loss" for the week
6. Balance the bank by adding (a profit) or subtracting (a loss) from the previous week's value and adding money received from the purchase to the total
7. Buy a stock and record the amount of money they spend

MATERIALS NEEDED

calculators (essential); a copy of the financial section of the paper that includes closing stock quotations for each group; a copy of the "Buying More Stock" blackline for each group

PROCEDURES

Students must agree on and buy a stock early in the data collection process. This is time consuming and cannot be rushed. The two most important processes in this transaction are (1) to keep track of the profit or loss for the stocks the group has not sold, and (2) to find the closing price for the stock to be bought during the current week with the money the group received from the previous week's sale.

The amounts are separated in the stock sheet so that the students will not be confused by the transaction. Students must be cautioned to keep the amount of money they still have invested in stock separate from the value of the stock they are buying this week. There is a tendency to "double-dip"—to count this money twice! If the value of the group goes up by a couple of thousand dollars, check to see that this has not occurred.

ASSESSMENT

1. Student products—Successful completion of blackline
2. Observation of students

Buying More Stock

Names ______________________________

____

Date ______________________________

Class ______________________________

Week # ______________________________ Date of newspaper ______________________________

Use this sheet on a week when your group is keeping track of stocks and buying one stock. You will also balance your checkbook by filling out the bottom section.

Abbreviation for stock	Number of shares purchased	Closing cost of stock in LAST WEEK'S paper	Closing cost of stock in TODAY'S paper	+ or – (How much?)	Profit (+) or loss (–) this week multiplied by number of shares

Profit or loss for this week (sum of last column) ______________________________

Use this space to purchase stock with the money you obtained from the sale last week. The amount of money you have to spend can be found on the "Planning to Sell" sheet of last week. Do not include this stock with your profit or loss, but be sure to add the value to your worth.

Name of stock you are selling	Abbreviation of stock	Cost per share	Number of shares purchased	Total value of this stock buy*

**This cannot exceed the amount of your sale last week*

A. Last week our stocks were worth (see last week) ______________________________
(Do not include the money you received from the sale of the stock last week!)

B. Total value of this stock purchase ______________________________

C. Profit or loss this week ______________________________

D. This week our group is worth [(A+B) ± C] ______________________________

Our Final Sell Week

MATHEMATICAL CONNECTIONS

fractions, decimals, computation, problem solving

INTELLIGENCES

logical/mathematical, interpersonal

OTHER CURRICULAR CONNECTIONS

Social Studies: Current events, economics

Language Arts: Reading tables, reading nonfiction

CONCEPTS

Students will do the following:

1. Find and record the closing prices of their stocks in the newspaper for the current week
2. Convert the mixed numbers to decimals and record the price
3. Calculate the value of the stock at the closing price
4. Balance the bank by adding the money received from

the sale of their stocks to any money that remains unspent (in the bank)

5. Determine the total value of their group at the end of this project

MATERIALS NEEDED

calculators (essential); a copy of the financial section of the paper that includes closing stock quotations for each group; a copy of "The Final Sale" blackline for each group

PROCEDURES

At this point, students will be selling all of their stocks to determine the total value of their group at the end of the project. For this reason, they are not concerned with the value of the stock in last week's paper but only with the closing costs for the current week.

For example, if the total value of their sale is $15,200, then the group made a profit of $5,200 (since they began the project with $10,000.) They can compute their percentage of profit:

$$\text{\% of Profit} = \frac{\text{difference (5,200)}}{\text{original money (10,000)}} = 0.52 = 52\%$$

This group did very well in their adventures in the stock market!

ASSESSMENT

1. Student products—successful completion of blackline
2. Observation of students

The Final Sale

Names ____________________

____

Date ____________________

Class ____________________

Week # ____________________

Date of newspaper ____________________

Use this sheet when your group is planning to sell all of its stocks at the end of the project. You will also balance your checkbook by filling out the bottom section.

Name of stock	Abbreviation for stock	Closing cost per share	Number of shares to sell	Total money for selling this stock

Total receipt for today's sales ____________________

Balancing the Bank

Money from sale of stock $ ____________________

Money left in bank $ ____________________

At the end of this project we have $ ____________________ (total)

Now you can calculate your percentage of profit by using this simple formula:

$$\text{Our percentage of profit} = \frac{\text{amount of profit}}{\$10{,}000} \times 100$$

Grading Matrix

Names ______________________

____

Date ______________________

Class ______________________

Criteria	**4**	**3**	**2**	**1**
Quality and completeness of weekly reports				
Quality and completeness of graphs				
Accuracy of "buys" and "sells"				
How well group worked together				
Accuracy and completeness of final results				

Comments:

Additional Reading

Fisher, C. P. 1993. *The stock market explained for young investors*. Woodside, Calif.: Business Classics.

A comprehensive look at the stock exchange, stocks, stock ownership, investments, and stock options for young investors.

Hiebert, R. E. 1970. *The stock market crash, 1929; Panic on Wall Street ends the Jazz Age*. New York: F. Watts.

This nonfiction book describes the 1929 stock market crash with emphasis on the nine most important days between September 3 and November 13. The causes and effects of the crash are briefly discussed with some discussion of economic depressions.

Little, J. B. 1987. *What is a share of stock?* New York: Chelsea House.

From the series "The Basic Investor's Library," this book tells young investors what a stock is and about public corporations.

———. 1988. *Reading the financial pages*. New York: Chelsea House.

Another book from the "The Basic Investor's Library" series, this resource tells young investors how to interpret the tables and graphs of stock price information and other financial news in newspaper business pages.

Millichap, N. 1994. *The stock market crash of 1929.* New York: New Discovery Books.

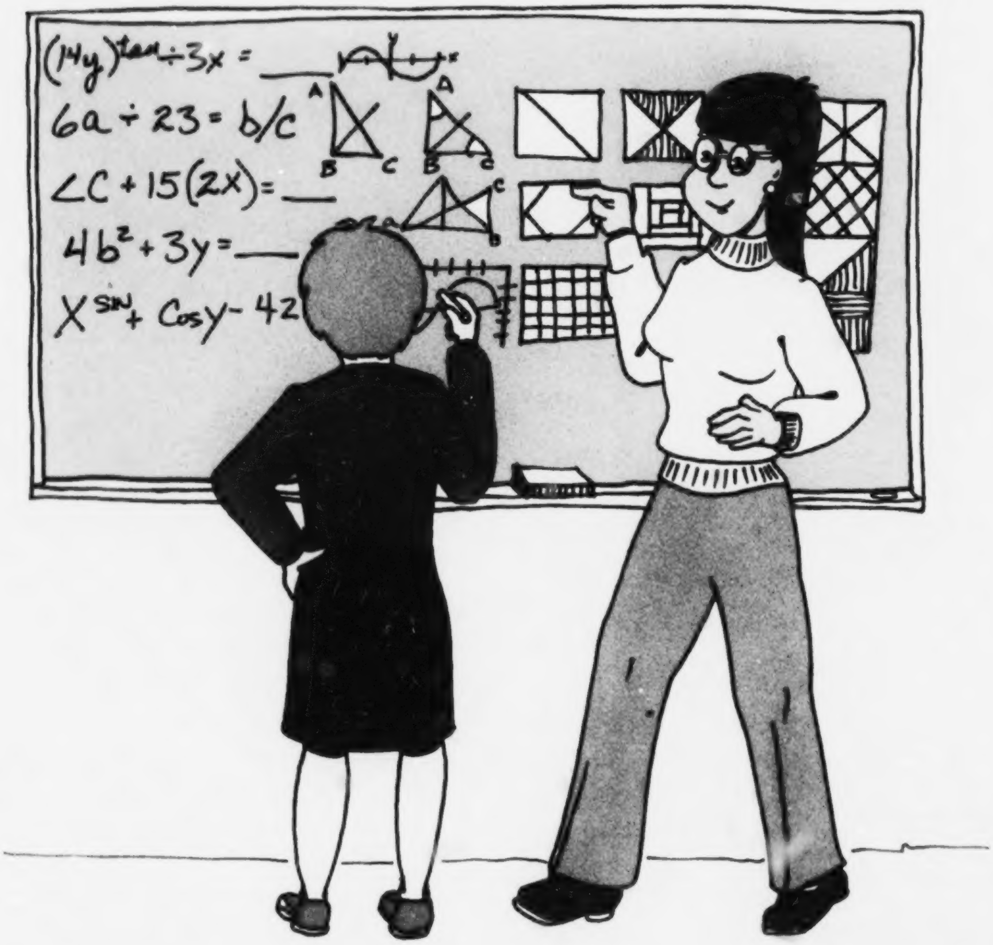
This nonfiction book written for young readers describes the New York Stock Exchange, the stock market crash of 1929, the Great Depression that followed, and the economic conditions in the United States from 1918 to 1945.

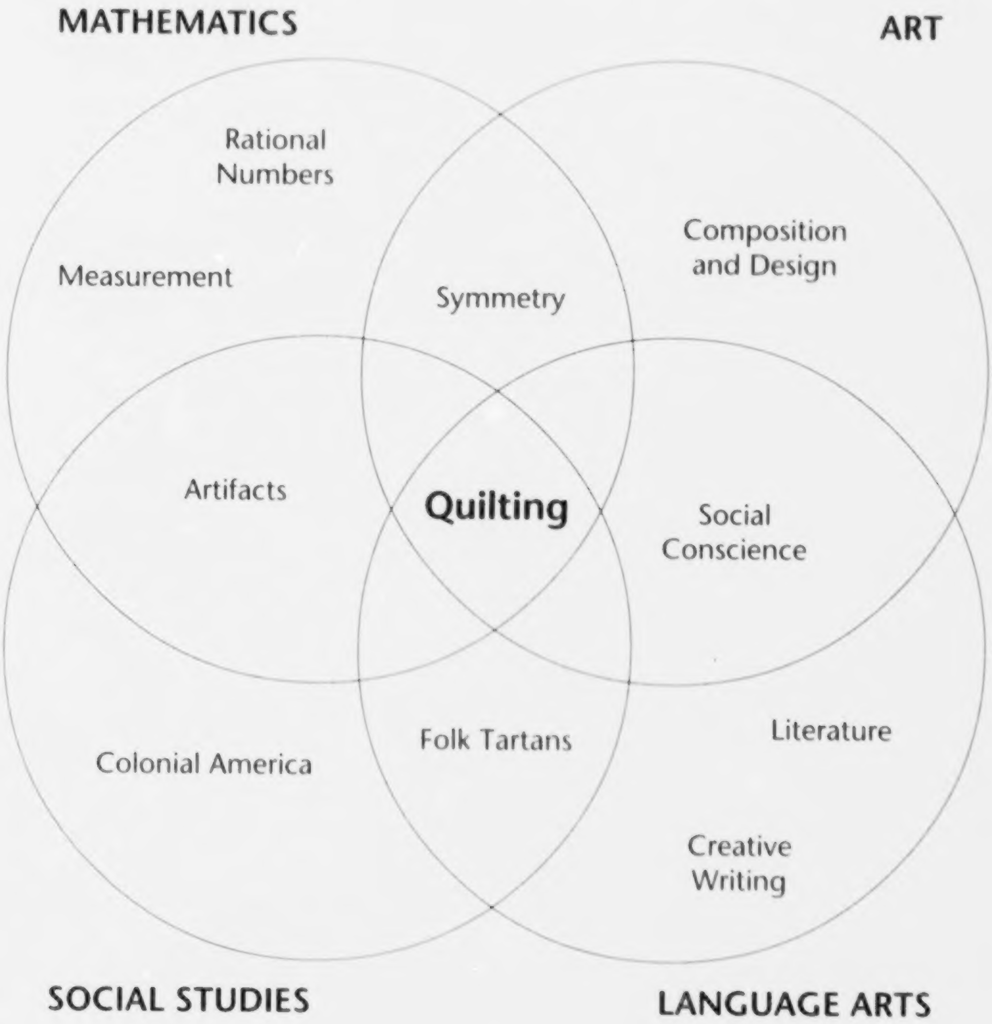
Sharmat, M. 1994. *Hello . . . this is my father speaking.* New York: HarperCollins.

Jeff Whitty is embarrassed that his father cleans offices for a living, so he invests in the stock market. His desire is to make enough money to allow his father to quit his job.

CHAPTER 5

Quilting across the Curriculum


(14y)tan ÷ 3x =
6a ÷ 23 = b/c
∠C + 15(2X) =
4b² + 3y =
X sin + Cosy - 42
A
B
C
A
B
C


MATHEMATICS
ART
Rational Numbers
Measurement
Symmetry
Composition and Design
Artifacts
Quilting
Social Conscience
Colonial America
Folk Tartans
Literature
Creative Writing
SOCIAL STUDIES
LANGUAGE ARTS

CHAPTER 5

Quilting across the Curriculum

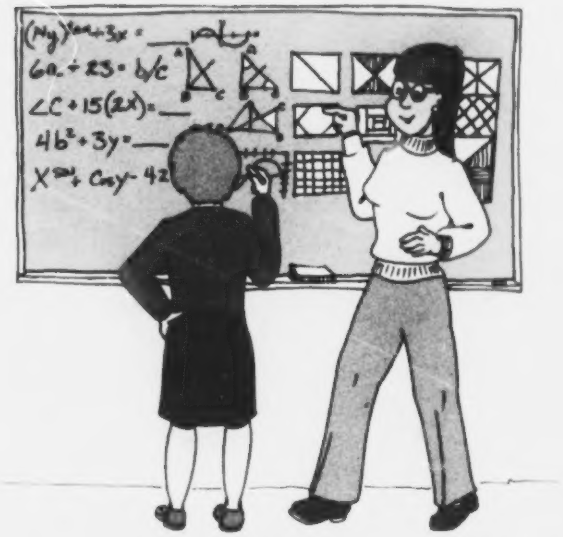
Quilting projects can be integrated into the study of social studies, language arts, mathematics, and art. They provide the types of physical experiences necessary to enhance the bodily/kinesthetic intelligence and they develop strong interpersonal and intrapersonal skills. When students work together to make a quilt, they join a quilting bee—a social group intended to foster cooperation and friendship.

The social studies component examines the challenging life of colonial Americans. It was a difficult life for pioneers. They did not have shopping malls to supply their everyday needs. Women had to make their own fabric—a process that sometimes took longer than a year. This process involved spinning the yarn and dying it to make it colorful, and then weaving it into cloth. Is it any wonder that even when clothes could no longer be worn, the fabric was saved to be used for another purpose? Every scrap of fabric was saved to form the small geometric shapes in quilts.

These quilts have become a part of our folk culture, as the lives of families are reflected in the colorful squares of patchwork. The quilts and their stories are chronicles of our sometimes joyous and sometimes sad pasts.

Quilts are tied to art through design and symmetry. The combination of colors, the placement of colors, and the design of the blocks can make dramatically different patterns. Complicated patterns can be created using only two different blocks of four-squares. These creative choices make the design process an exciting and enriching experience.

Mathematically, we can examine the symmetry of quilts and the accurate measurement required to produce the design. In addition, we can describe the blocks by describing the fractional part each of the colors of fabric represents. Students first combine squares and triangles into pleasing patterns and then substitute fabrics (of various hues) for the light and dark sections. Finally, these scraps of fabric are sewn into blocks. The class quilting bee then combines individual blocks into a larger class quilt.



The Mathematics of Quilts

MATHEMATICAL CONNECTIONS

fractions, percents, symmetry, transformational geometry

INTELLIGENCES

visual/spatial, interpersonal, intrapersonal, logical/mathematical, verbal/linguistic, bodily/kinesthetic

OTHER CURRICULAR CONNECTIONS

Social Studies: Quilting and Colonial America, The African-American experience and quilting

Language Arts: Creative writing, reading fiction and nonfiction

Art: Design and symmetry

CONCEPTS

Students will do the following:

1. Design quilt blocks using geometric transformations
2. Calculate fractional parts and percents of their blocks
3. Examine the symmetry of quilts

MATERIALS NEEDED

a copy of each blackline in the section for each student; crayons, markers, or colored pencils; calculators

PROCEDURES

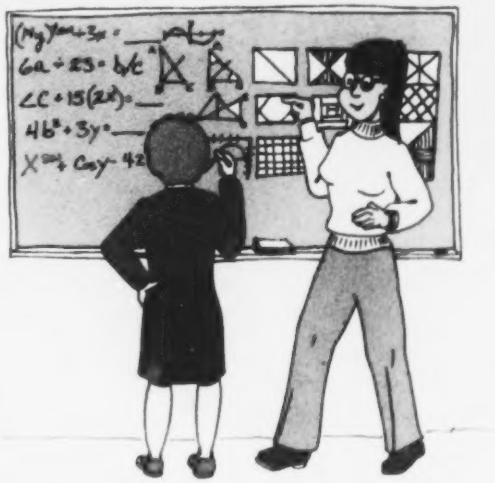
Discuss with students the history of quilts, the four-patch, and the nine-patch. After students have calculated the fractional parts of "Jacob's Ladder" they can use the squares and triangles to design their own quilt block. Fascinating and unique designs can be made by using slides, rotations, and reflections. Encourage students to use between three and five colors for their designs. The colors should be variations of hue ranging from light to dark.

If an actual quilt is going to be constructed, choose five different shades of fabric: light, medium light, medium, medium dark, and very dark. These variations will add interest to the quilt. You want to avoid using colors that have the same sized pattern and density of hue.

A class quilt can be made out of the paper designs by pasting them all on a larger piece of paper. It is also possible to use fabric crayons. These crayons are available at fabric stores. If you cannot find them, call 800-CRAYOLA to find the nearest retailer. You can color the design using these special crayons and transfer them, using an iron, onto a piece of fabric. The class quilt is compeleted once the squares are sewn together.

ASSESSMENT

1. Student products—Successful completion of design and blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "Explain how the same combination of geometric shapes can be used to produce entirely different quilt blocks. Give an example using a diagram."



Four-Patch and Nine-Patch

Names ______________________

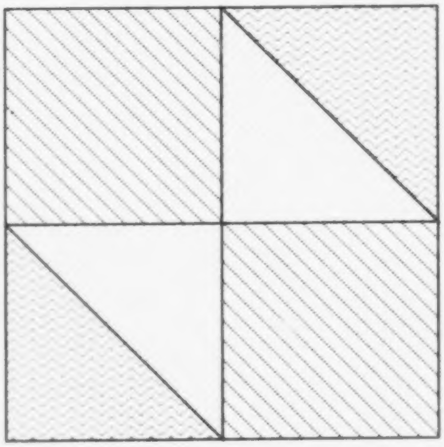
____

Date ______________________

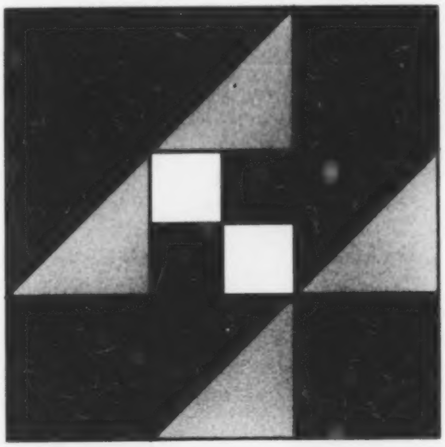
Class ______________________

Throughout American history, quilts have held a special place in the hearts of many. Almost everyone is fascinated by their geometric design, their remarkable symmetry, and the intricate and delicate work that goes into producing them. What is a quilt? It is actually three different layers: the artistic top, a warm and fluffy filling, and a backing—all held together with decorative stitching.

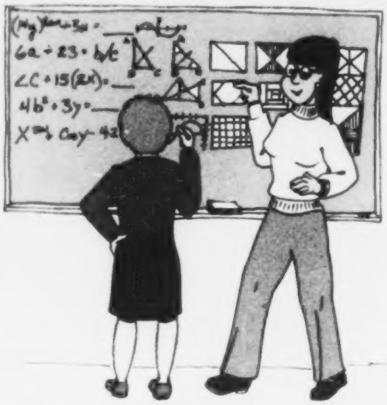
The attractive top is actually pieces of fabric made into squares; these smaller squares are then "pieced together" to make larger squares (or blocks.) The blocks are pieced together, finally producing a quilt. The pieces can be squares, triangles, rectangles, parallelograms, circles, or other geometric shapes. These shapes are pieced into blocks called four-patches or nine-patches. Examples of these are pictured below.



A Four-Patch
4 Triangles and 2 Squares



A Nine-Patch
8 Triangles, 4 Large Squares, and 4 Small Squares



Jacob's Ladder

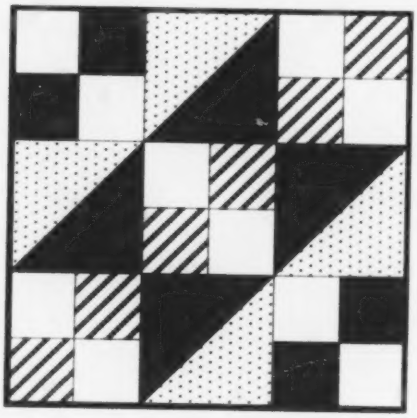
Names ______________________________

____

Date ______________________________

Class ______________________________

This nine-patch is called "Jacob's Ladder." Let's examine it for its mathematical significance.



If we consider the whole square equal to 1 whole,

What fractional part of the square is ■ ? ______

What fractional part of the square is ▨ ? ______

What fractional part of the square is □ ? ______

What fractional part of the square is ■ ? ______

What fractional part of the square is ░ ? ______

Does it appear to have a line of symmetry? ______________________________

Explain why this square is called Jacob's Ladder. ______________________________

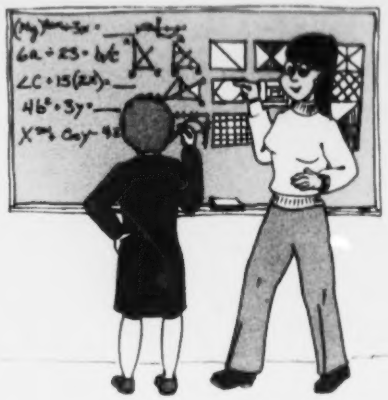
____

____

____

____

____



Templates

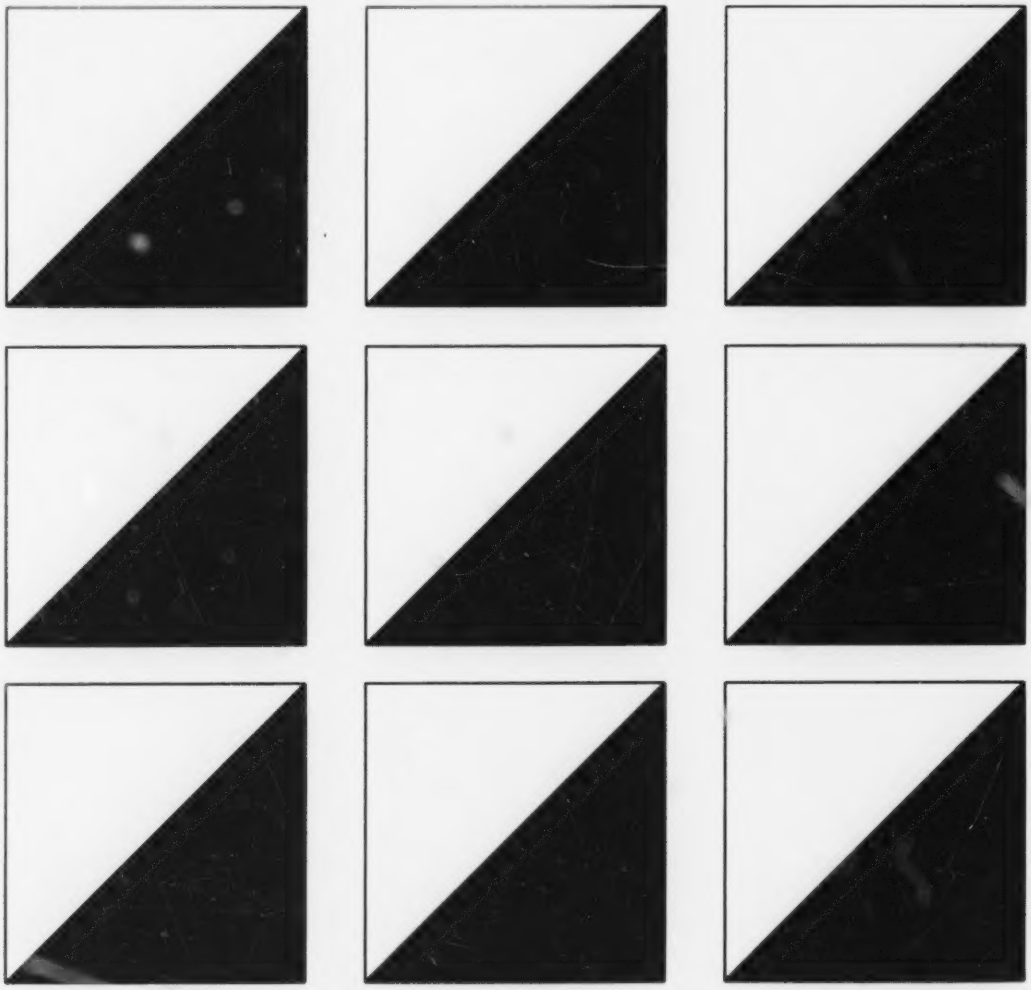
Names ______________________________

____

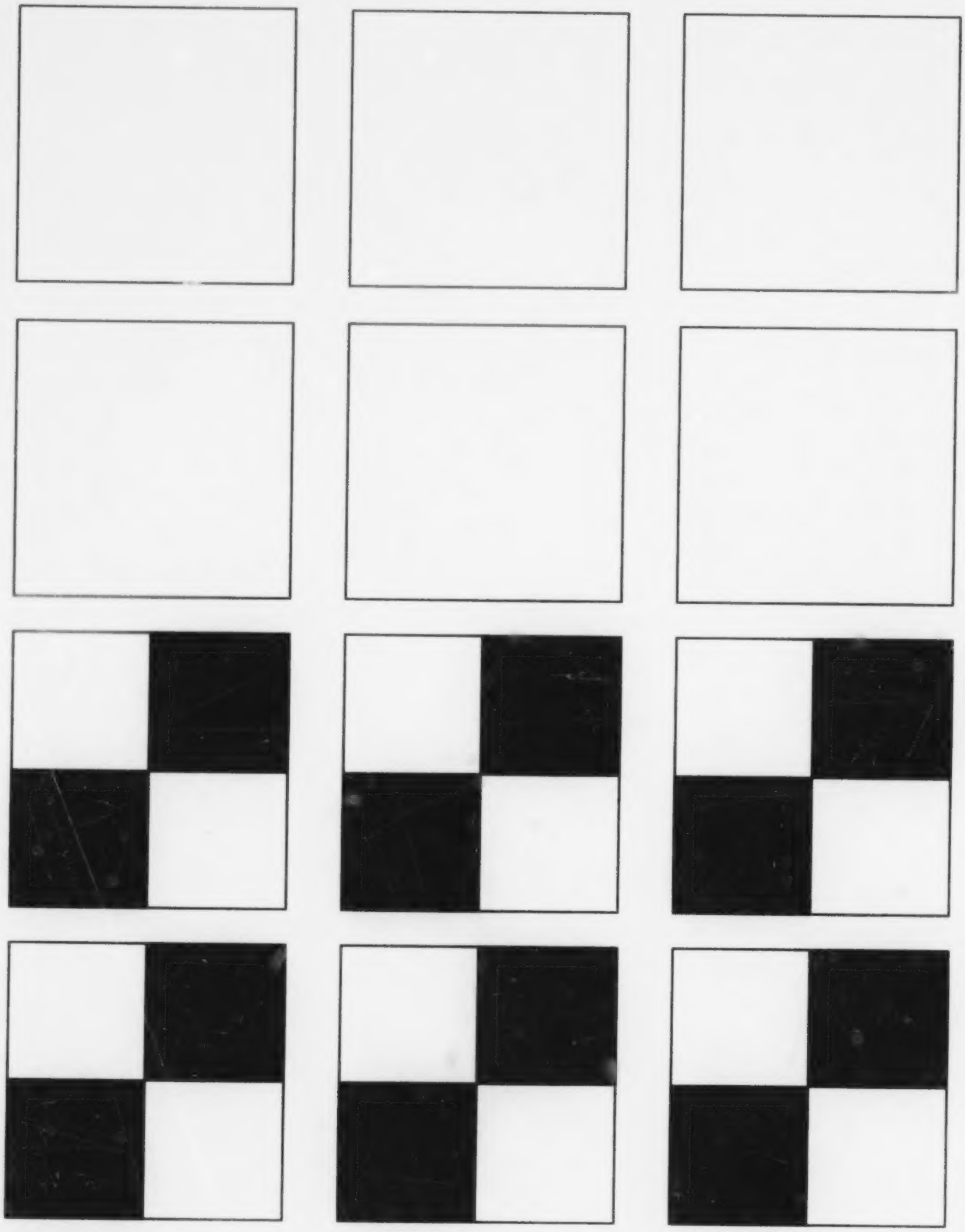
Date ______________________________

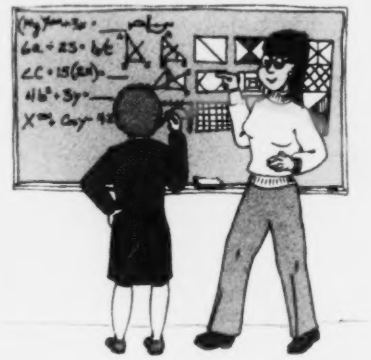
Class ______________________________

Use the templates below to form an interesting design for your quilt. By combining squares and rotating triangles, wonderful quilt patterns can be formed. This page contains triangles, the next page contains squares. After designing your quilt, color it with crayons or markers.



Templates (Continued)





Quilt Grid

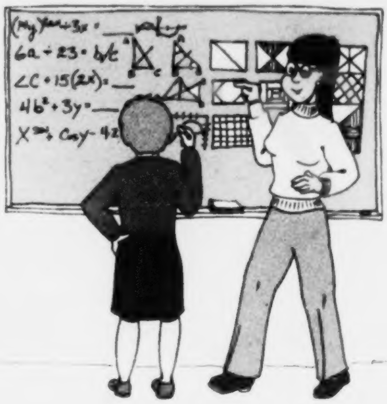
Names ____________________

____

Date ____________________

Class ____________________

Use this grid to design your quilt using the template polygons. Be sure to color the "different fabrics"; use only four colors.



What's in the Design?

Names ______________________

____

Date ______________________

Class ______________________

Use your quilt design to answer these questions.

Color	Number of Squares	Fraction of the Block	Percent of the Block
Total			

Describe the relationship between the number of squares of a color and the fractional part and the block. ______________________

____

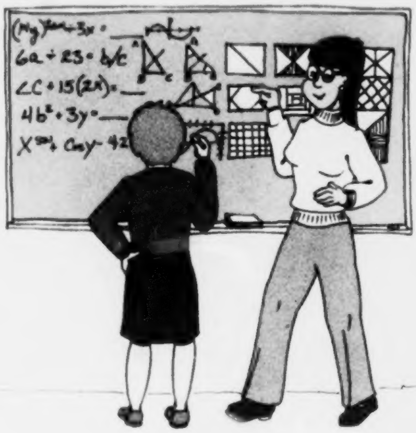
____

Describe the relationship between the number of squares of a color and their percentage of the block. ______________________

____

____

____



Grading Matrix

Names ______________________

____

Date ______________________

Class ______________________

Criteria	4	3	2	1
Accuracy of computation of quilt square				
Understanding of Jacob's Ladder				
Overall quality of project				

Comments:

Additional Reading

Campbell, L. 1983. *Sam Johnson and the blue ribbon quilt.* New York: Mulberry Books.

While mending the awning on a pigpen, Sam discovers that he enjoys sewing the patches of fabric together. When he asks to join his wife's quilting club, his request is met with jeers and scorn—but Sam Johnson has the last laugh!

Coerr, E. 1985. *The Josefina quilt story.* New York: Harper and Row.

While traveling west with her family in the 1850s, a young girl makes a patchwork quilt that serves as a journal of their experiences.

Flourney, V. 1985. *The patchwork quilt.* New York: Viking Penguin.

Tanya's grandmother makes a quilt to chronicle a very important year. A touching story that explains the importance of this very special quilt.

Hopkinson, D. 1993. *Sweet Clara and the freedom quilt.* New York: Alfred A. Knopf.

A young slave stitches a quilt with a map pattern that guides her to freedom.

Johnson, T. 1985. *The quilt story.* New York: G. P. Putnam.

Abigail is warmed and comforted by a quilt her mother stitched. Many years later, the same quilt is mended for another little girl.

Kinsey-Warnock, N. 1989. *The Canada geese quilt.* New York: Dell Publishing.

Ariel and her grandma start working on a quilt for the new baby in the house. But when Grandma becomes ill, Ariel struggles to finish the quilt on her own. Meanwhile, Grandma has a secret gift planned for Ariel.

McKey, E. 1989. *The memory quilt.* Mt. Desert, Maine: Windswept House.

After the death of his mother and father, Ethan's grief is eased by Grandma's Memory Quilt.

Polacco, P. 1988. *The keeping quilt.* New York: Simon and Schuster.

Four generations of an immigrant Jewish family are tied together by the memories of a homemade quilt. The quilt becomes a symbol of their enduring love and faith.

Reingold, F. 1991. *Tar beach.* New York: Crown Publishers.

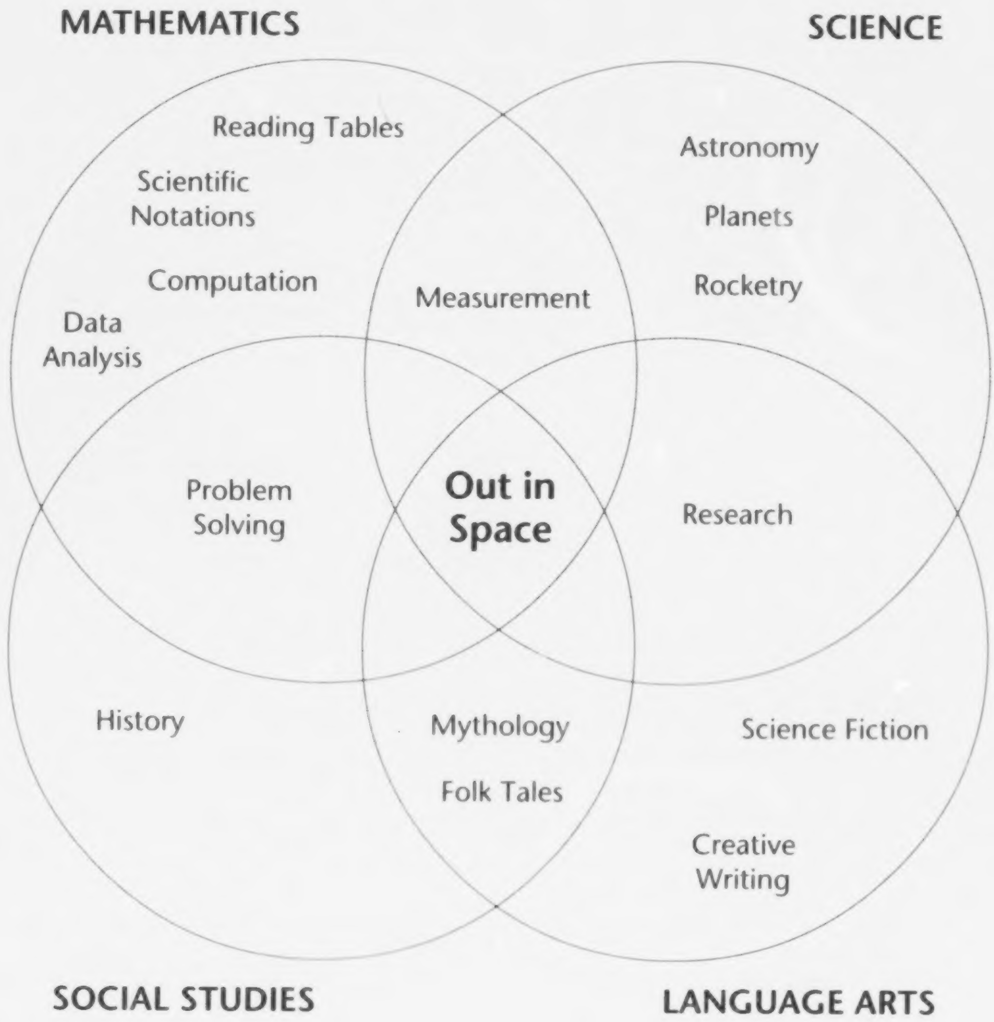
The dreams of a young girl who flew over her home in Harlem and claimed all that she saw for herself and her family. The story is told through the designs of quilts, and at the end, her life is protrayed as a quilt.

SECTION II

Shared Explorations

CHAPTER 6

Out in Space


MATHEMATICS
SCIENCE
Reading Tables
Scientific Notations
Computation
Data Analysis
Measurement
Astronomy
Planets
Rocketry
Problem Solving
Out in Space
Research
History
Mythology
Folk Tales
Science Fiction
Creative Writing
SOCIAL STUDIES
LANGUAGE ARTS

CHAPTER 6

Out in Space

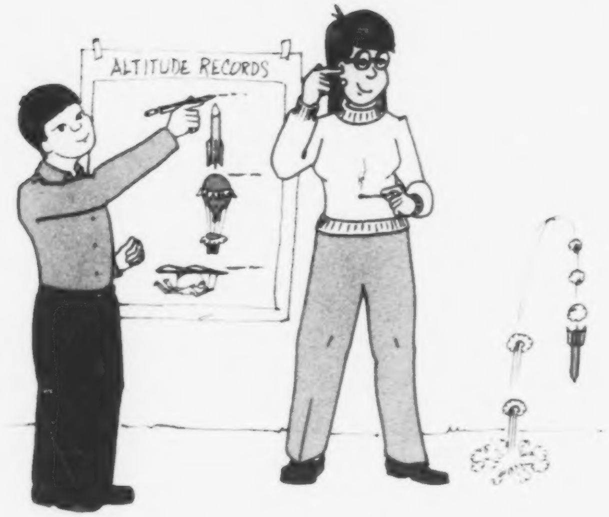
Time and again the scientific world uses mathematical ideas in its efforts to unravel the mysteries of the universe.

—Theoni Pappas

The mathematics lessons in this chapter can be loosely tied with overlapping concepts being taught in two or more classrooms. Astronomy and space exploration are part of the middle school science and social studies curriculum, and, since mathematics is the language of science, the lessons in this chapter can be shared and taught in cooperation with other teachers of a middle school team.

The rocket altitude lesson begins with a table of record rocket firings. The dates span from 1790 to 1972 and document heights ranging from 0.71 miles (about 3,749 feet) to more than 3.7 billion miles. In the mathematics class, this information can be used to compare numbers and convert them from standard to scientific notation. In social studies, students can examine the historical events paralleling these scientific records. In language arts, students can read the literature of space travel and examine rocket technology in science. The integration of topics allows students to see the problem from multiple perspectives.

Driving to the Sun is another lesson that is easily shared between disciplines. In math class, students can compute how long it would take to get to the sun at a speed of 55 miles per hour, while in language arts they can read the Greek myth of Daedalus and Icarus. Students can explore what the earth was like before leaving for the sun and what it would be like after returning. If they arrived at the sun today, they would have started their journey in the late 1700s. What was happening in the world when they left Earth? If they turned right around and reversed their course, what would the earth be like when they got back?



Rocket Altitude Records

MATHEMATICAL CONNECTIONS

reading tables, comparing numbers, scientific notation, analysis of graphing

INTELLIGENCES

interpersonal, intrapersonal, logical/mathematical, verbal/linguistic

OTHER CURRICULAR CONNECTIONS

Science: Rocketry and space travel

Social Studies: The growth of rocket technology and world conditions

Language Arts: Creative writing: "Describe the sights that appear out of the window of your spaceship as you travel in the rocket launched in March 1972."

CONCEPTS

Students will do the following:

1. Examine data and consider visual representations
2. Calculate the difference between very large and very small numbers

3. Convert numbers from standard notation to scientific notation

MATERIALS NEEDED

calculators; copies of the unit's blacklines for each student

PROCEDURES

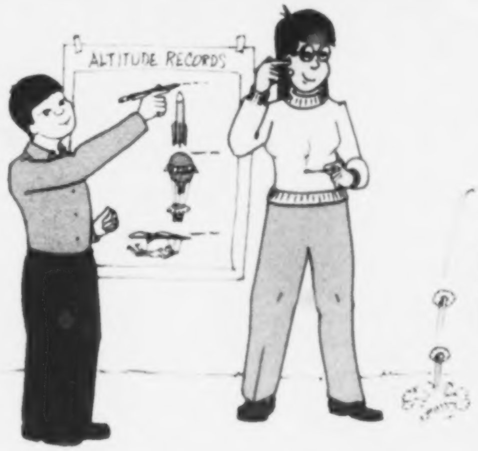
Examine data in the table and discuss the dates that most of the space flights took place. The table lists record heights achieved by rockets between 1790 and 1972. It is not a comprehensive list of rockets fired. An interesting discussion can develop concerning the hiatus between the first and second firing and what was happening on Earth in the 1790s. (Some research can be done to find out what actually happened at that time.)

The firings during the 1930s and 1940s were attempts by the Germans (during World War II) to fire a rocket as an offensive weapon. The purpose of the firings after the 1950s was a combination of weapons development and attempts at space flights and explorations.

The exercises accompanying the table require students to compare numbers of very different magnitudes and convert them into scientific notation. Because of the diversity and lack of consistency of the data, I do not believe it is possible to design a meaningful graph from it. (If one of your students designs a graph that accurately and meaningfully represents the data, please send it to me. I would love to see it. And, in appreciation for your help, I will send you a free copy of this book.)

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "Explain in your own words the advantage of using scientific notation for very large numbers."



Rocket Altitude Records

Names ______________________________

____

Date ______________________________

Class ______________________________

Below are the record heights attained by rockets fired from the earth between 1790 and 1972. Use this information to answer the questions that follow.

Height in Miles	Place	Launch Date
0.71	London, Great Britain	April 1790
1.25	Osnabruck, Germany	April 1931
3	Moscow, USSR	November 1933
52	Peenemünde, Germany	October 1942
85	Heidelager, Poland	early 1944
118	Heidelager, Poland	mid-1944
244	White Sand, NM, USA	February 1949
682	Cape Canaveral, FL, USA	September 1956
> 800	Tyuratam, USSR	August 1957
> 2,700	Enewetak Atoll (Marshall Islands)	October 1957
70,700	Cape Canaveral, FL, USA	October 1958
215,300,000*	Tyuratam, USSR	January 1959
242,000,000*	Tyuratam, USSR	November 1962
3,666,000,000**	Kennedy Space Center, Cape Canaveral, FL, USA	March 1972

**Apogee in solar orbit.*

***Distance when it crossed Pluto's orbit in 1986; it is now even deeper in space.*

ALTITUDE RECORDS

Making Sense of the Numbers

Names ______________________________

____

Date ______________________________

Class ______________________________

Do you think you could design a graph with this data? Explain your answer. ______________________________

____

____

How many times higher did the last rocket soar than the first? ______________________________

Explain how you solved this problem. ______________________________

____

____

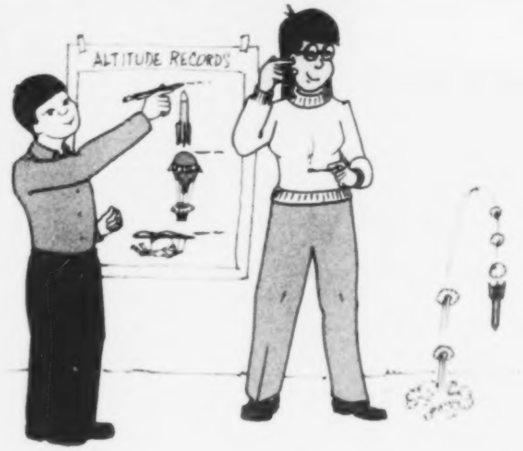
Very large or very small numbers are best described using scientific notation. We write numbers in scientific notation as $a \times 10^{n}$ where $1 \leq a < 10$.

For example: $24{,}000 = 2.4 \times 10^{4}$ using scientific notation.

A number < 1 (e.g., 0.45) uses a negative exponent: $0.45 = 4.5 \times 10^{-1}$.

Put these numbers into scientific notation by filling in the correct numbers in the table.

Original Number	$1 \leq a < 10$	Power of 10	Number in Scientific Notation
0.71	7.1		
1.25			
3			
52			
85			
118		10^{2}	
244			
682			
> 800			
> 2,700			
70,700			
215,300,000			
242,000,000			
3,666,000,000			



Grading Matrix

Names ______________________

____

Date ______________________

Class ______________________

Criteria	4	3	2	1
Accuracy of computation				
Quality of group activity				
Overall quality of project				

Comments:

Driving to the Sun

MATHEMATICAL CONNECTIONS

computation, problem solving, using conversion factors

INTELLIGENCES

interpersonal, intrapersonal, logical/mathematical, verbal/linguistic

OTHER CURRICULAR CONNECTIONS

Science: Light-years, the solar system

Social Studies: History of the early 1800s (as it relates to your curriculum), research

Language Arts: Creative writing: "Suppose you left the sun today to drive back to Earth. Describe what Earth might look like when you arrive"; "Write a myth about the sun and its relationship to men and women."

Literature: Greek mythology—Daedalus and Icarus (Icarus flew too close to the sun)

CONCEPTS

Students will do the following:

1. Predict the amount of time it might take to drive to the sun

2. Use conversions to change units of time
3. Make connections between mathematics and science, social studies, language arts, and literature

MATERIALS NEEDED

calculators; copies of blacklines from this section for each student; reference books to research the history of the early 1800s

PROCEDURES

Ask students to predict how long it would take them to drive 93,000,000 miles if their rate was an average of 55 mph. Write down the predictions and save them for future reference.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "If you had driven at the rate of 65 mph, how much faster would you have reached the sun?"

Are We There Yet?

Names ______________________

____

Date ______________________

Class ______________________

The sun is 93,000,000 miles from Earth. That's a long distance away!

If you drove a car at a speed of 55 mph, how long would it take you to drive to the sun?

Make an estimate of the time it would take and write it here ______________________

____

Use this space to find the actual time:

How long did it take to drive to the sun? ______________________

If you reached the sun today, in what year would you have started on your journey? __________

____

____

Looking Back

Names ______________________________

____

Date ______________________________

Class ______________________________

You have calculated the year you began your journey to the sun. What was our world like at that time? What were the headlines of the day? What was life like for a person of your age? Do some research to find out what was happening in that year. Then, write a story about the life of a child who lived the year you left Earth to drive to the sun.

Grading Matrix

Names ______________________________

____

Date ______________________________

Class ______________________________

Criteria	4	3	2	1
Accuracy of computation				
Quality of group activity				
Quality of written responses				
Overall quality of project				

Comments:

Additional Reading

Abrams, H. N. 1992. *Newton: The father of modern astronomy.* New York: Harry N. Abrams, Inc.

The story of the life and contributions of Isaac Newton, one of the most distinguished scientists of the seventeenth century. This book details his invention of the reflecting telescope and his explanations of the nature of light and the laws of gravitation. Newton paved the way for the discoveries of modern astronomy.

———. 1992. *The sky: Mystery, magic, and myth.* New York: Harry N. Abrams, Inc.

The stories of the myths and legends that men and women have invented while staring into the heavens and observing the stars.

Bell, T. H. 1963. *The riddle of time.* New York: Viking Press.

An examination of how people have measured time from the viewpoint of physics, astronomy, geology, biology, and psychology.

Jastrow, R. 1977. *Until the sun dies.* New York: W. W. Norton.

A look at twentieth-century discoveries in astronomy, space exploration, the history of life on earth, the evolution of human beings, and the possibility of life on other planets.

Lasky, K. 1994. *The librarian who measured the earth.* Boston: Little, Brown & Co.

A picture book that describes the life and work of Eratosthenes, a Greek geographer, astronomer, mathematician, and librarian. The book details how Eratosthenes was able to accurately measure the circumference of the earth.

Latham, J. L. 1955. *Carry on, Mr. Bowditch.* Boston: Houghton Mifflin.

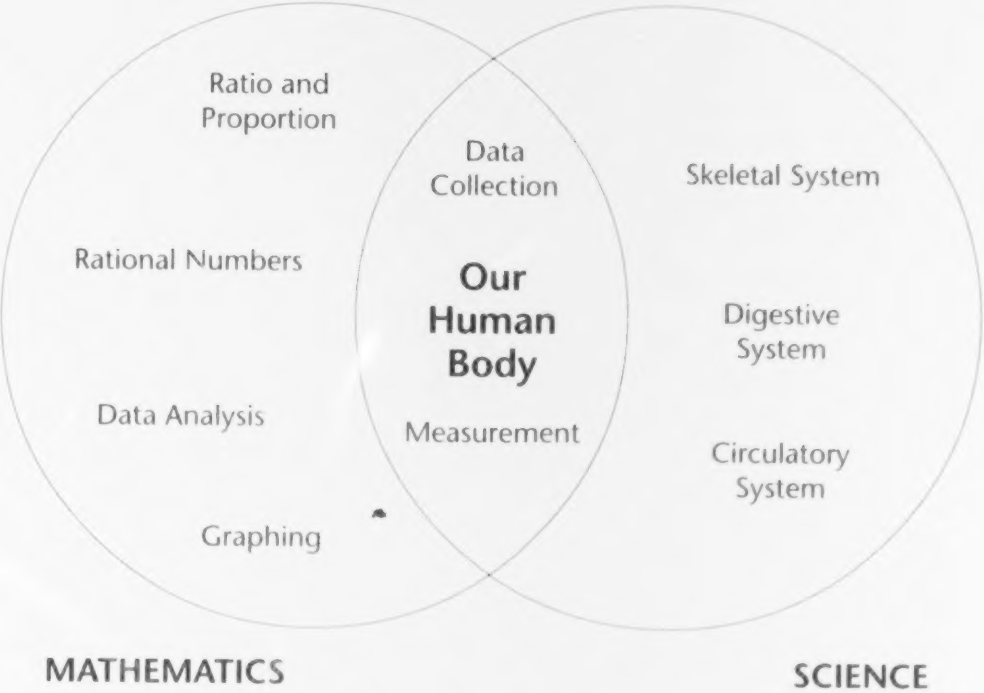
Nathaniel Bowditch was apprenticed to a shipbuilder in Boston at the age of twelve. He spent his nights studying about ships, the sea, mathematics, and astronomy. Later he wrote *The American Practical Navigator,* which is the standard text on navigation.

McCaughrean, G. 1993. *Greek myths.* New York: MacMillan Publishing.

Includes many of the famous Greek myths, including that of Daedalus and Icarus.

CHAPTER 7

Our Human Body


Ratio and Proportion
Rational Numbers
Data Analysis
Graphing
Data Collection
Our Human Body
Measurement
Skeletal System
Digestive System
Circulatory System
MATHEMATICS
SCIENCE

CHAPTER 7

Our Human Body

Mathematics is the language of science. The projects in this chapter allow science and mathematics teachers to connect these two disciplines naturally, using a shared model of integration. In mathematics, students focus on measurement, ratios and proportions, fractions, decimals, data collection and analysis, problem solving, and percentages. In science, students work on the human anatomy, including the circulatory, digestive, and skeletal systems.

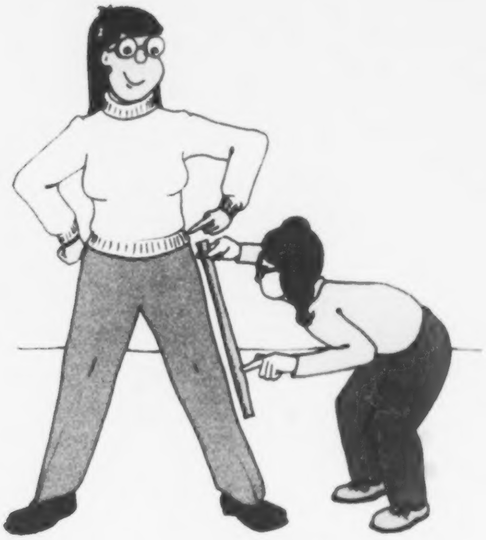
The abstract concept of a numerical constant is simplified through the hands-on experimentation in "The Body's Ratios" lesson. By discovering the constant decimal ratio between an individual's height and the distance from her head to her waist, students obtain a concrete understanding of the meaning of constant.

Students learn in the "Our Remarkable Heart" lesson that the heart beats about seventy times each minute for about seventy years. They compute how many times it beats, how many gallons it pumps each day (more or less than a bathtub full?), and how its beat changes during exercise. The heart beats in perfect four-four time. The musical/rhythmic and verbal/linguistic intelligences can be utilized by writing songs (words and music) to the beat of the heart.

The remarkable ratios found in our body are highlighted again in "The Thighbone's Connected to the . . ." lesson. By using a formula, students can very closely approximate their actual height by measuring their femur (or thighbone). Was studying mathematics and science ever this much fun?

The digestive system is another remarkable feat of engineering. It has been called a "disassembly line" because of the way it takes food and breaks it down rather than putting it together. The digestive system consists of eleven major parts, starting at the mouth and ending at the anus. Just how long is our digestive system, anyway?

And, finally, "What Are Your Favorite Foods?" encourages interpersonal skills while allowing students to collect, organize, analyze, and graph data. Since our taste buds respond to only four tastes (sweet, salty, sour, and bitter), students are asked to categorize their classmates' favorite foods into these categories. Where would you put a hot dog or hamburger?



The Body's Ratios

MATHEMATICAL CONNECTIONS

measurement, ratio and proportion, fractions, decimals

INTELLIGENCES

logical/mathematical, bodily/kinesthetic, intrapersonal, interpersonal, visual/spatial, verbal/linguistic

OTHER CURRICULAR CONNECTIONS

Science: Life science, human anatomy

CONCEPTS

Students will do the following:

1. Measure the distance from their head to their waist
2. Measure their total height
3. Find the ratio of the two heights
4. Calculate the class mean
5. Understand the concept of a constant

MATERIALS NEEDED

tape measure and/or meter sticks; copies of "Find Your Body's Ratios" blackline for each student; overhead transparency of "Find the Class Mean" blackline

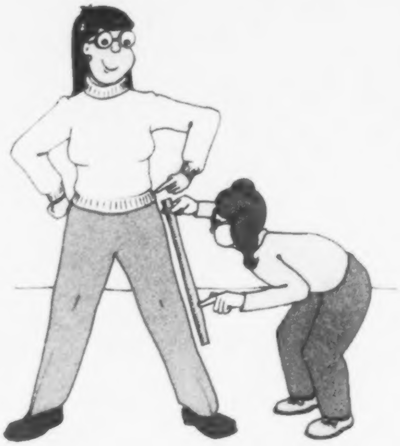
PROCEDURES

Ask students if they believe that all people have similar ratios between their height and the distance between their heads and their waists. Discuss the idea of proportion. What does it mean to be "in proportion?" Why do the movies represent extraterrestrial beings as having very big heads or as being extremely thin? Why do they look "strange"?

Allow students to work in groups of four to find the average ratio between the two measurements. (The ratio of total height: head to waist is about 2.5.) When each group has completed their data collection, have them enter their mean ratio on the "Find the Class Mean" blackline. The decimal equivalent can be used as a multiplier to predict the total height of a person if the distance from the head to the waist is known.

ASSESSMENT

1. Student products—Successful completion of blackline
2. Observation of students
3. Journal Question: "Explain how the ratio of 2.5 can be used to predict a person's height."



Find Your Body's Ratios

Names ______________________________

____

Date ______________________________

Class ______________________________

Directions: Works with your group of four to do the following:

1. Measure your total height.
2. Measure your height from your waist to the top of your head.
3. Set up the ratio of $\frac{\text{total height}}{\text{waist to head}}$ and convert that ratio into a decimal.
4. Record all this data for all the members of your group on the table provided.
5. Find the mean ratio for the group and record that on the class record.

Name	Total Height	Waist to Head	Ratio	Decimal
Mean (Average)			■	

As a group, describe in this space any interesting patterns you observed. ______________________________

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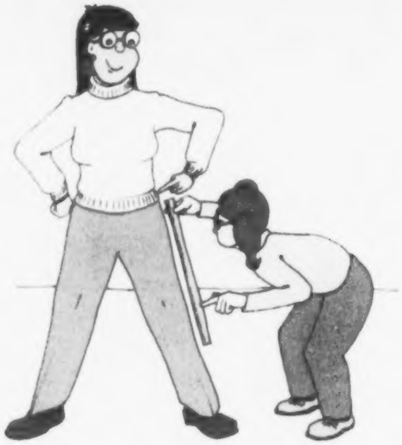


Find the Class Mean

Names ______________________

____

Date ____________ ____________

Class ______________________

Group	Average Ratio	Average Decimal
A		
B		
C		
D		
E		
F		
CLASS MEAN		

Does there appear to be a constant ratio between these two measurements? ______________

Could you use this number to predict someone's height if you knew the measurement from her head to her waist? How? ______________________

____

____

____

Grading Matrix

Names ______________________

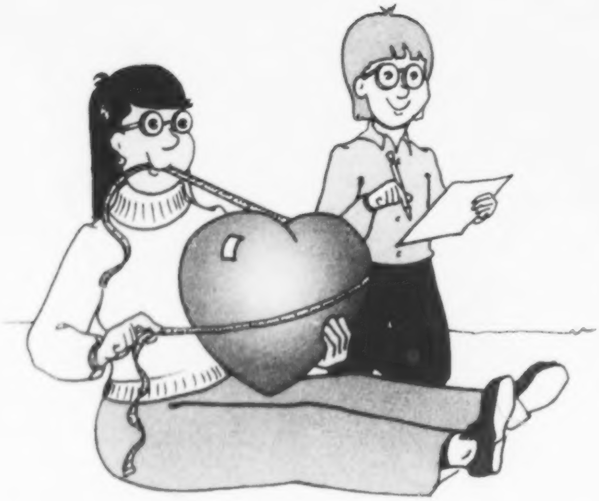
____

Date ______________________

Class ______________________

Criteria	4	3	2	1
Quality of data collection and computation				
Analysis of data; written work				
How well group worked together				

Comments:



Our Remarkable Heart

MATHEMATICAL CONNECTIONS

data collection and analysis, problem solving, computation

INTELLIGENCES

bodily/kinesthetic, logical/mathematical, intrapersonal, interpersonal, verbal/linguistic, musical/rhythmic, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Biological sciences, human circulatory system

Language Arts: "Describe the average day in the life of a red blood cell as it travels in inner space."

Literature: Biographies (e.g., Dr. William Harvey, Dr. Christiaan Bernard)

CONCEPTS

Students will do the following:

1. Collect data to compute their heart rates
2. Compute the volume of blood flow in one day
3. Collect data to compute the increase in heart rate during exercise

4. Problem solve the relationship between the volume of their bathtub and the volume of blood pumped in one day

5. Compose a song (lyrics and music) in four-four time

MATERIALS NEEDED

watches with second hands; copies of blacklines for each student; calculators

PROCEDURES

There are three different experiments and one lesson in this section. The first experiment encourages students to use scientific inquiry to find their average heart rate. By working in groups, students collect and use data to draw conclusions about heart rate and flow of blood. Discuss the importance of careful planning and measurement. Accurate timing and computation is required.

The second experiment, finding the volume of a bathtub, is more open ended. There are many ways students can find an approximate volume. Again, discuss the importance of careful planning. How can we measure a large quantity of water? An interesting problem!

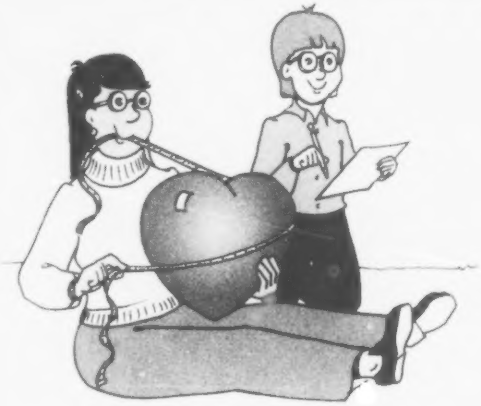
The third experiment examines the difference in heart rates when the body is at rest as opposed to during exercise. Again, precise timing and measurement is the key to success.

Once the experiments are complete, bring the groups together to discuss the average heart rate, the rate of flow, how much water a bathtub holds, how that volume relates to the amount of blood that travels through the body in one day, and how the heart rate is affected by exercise. Why does the heart rate increase during times of physical activity?

The last lesson asks students to relate the beat of their heart to a rhythmic beat in music. Since most hearts beat at a steady rate, its rhythm can be equated to a four-four beat; each measure contains four beats and a quarter note is worth one beat.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of student groups
3. Grading matrix
4. Journal question: "Discuss what you learned about your heart rate and volume of blood from your experiments."



How Many Beats?

Names ______________________________

____

Date ______________________________

Class ______________________________

Imagine a pump that weighs about one-half pound (about the size of a clenched fist) and works twenty-four hours a day for about seventy years! It has the power of a champion athlete and every hour produces enough energy to raise a small car off the ground. This remarkable pump is the human heart!

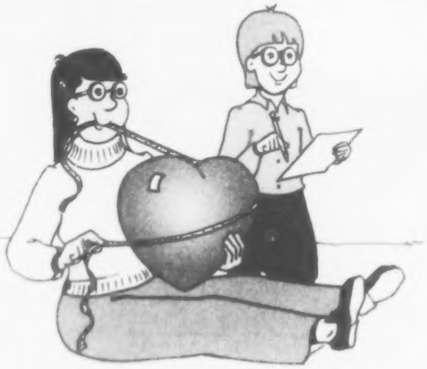
The heart is the body's key to survival. It pumps blood carrying a supply of food and oxygen to billions of cells and removes carbon dioxide and other wastes away from the cells. What a hard worker. But just how hard does it work? These activities will help us better understand our remarkable heart.

The average healthy adult heart averages seventy-two beats per minute. Do you think your heart beats faster or slower? How many times per minute do you think your heart beats? How many times do you think your heart beats in one day? In one year?

Directions: Work in your group to collect this data. Use a watch with a second hand. Count the number of times your heart beats in fifteen seconds. Use this data to compute the beats per minute, per hour, and per year.

Your Name	**Beats per 15 seconds**	**Beats per minute**	**Beats per day**	**Beats per year**
AVERAGE				

Use the averages from the table above to compute how many times a heart would beat in eighty years. Explain how you solved this problem:



How Much Blood?

Name ____________________

Date ____________________

Class ____________________

The average amount of blood pumped by the heart with each beat is about 5 ounces.

An adult heart beats at an average of 70 beats per minute or about 100,800 beats each day!

Use this information to compute the number of gallons of blood pumped every day through our blood vessels. The facts on this conversion table will help you with your computation:

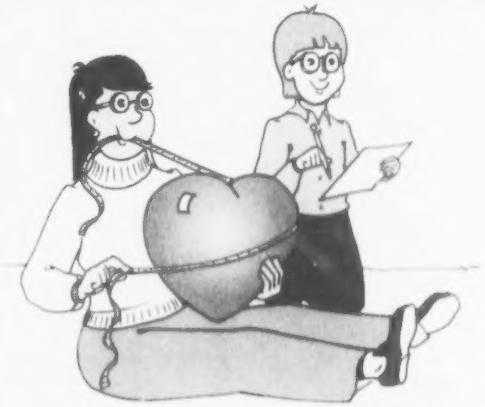
8 ounces = 1 cup
2 cups = 1 pint (16 oz)
2 pints = 1 quart (32 oz)
4 quarts = 1 gallon (128 oz)

How many gallons of blood does you heart pump? Use this space to explain your reasoning:

Now that you have computed the volume of blood pumped each day, let's conduct an experiment to attempt to understand how much blood this actually is.

How much water does your bathtub hold?

Your assignment for tonight is to calculate the volume of water it would take to fill your bathtub. How does this volume compare with the amount of blood your heart pumps in one day? Explain how you solved the bathtub problem:



How Fast Does Your Heart Beat?

Names ______________________________

____

Date ______________________________

Class ______________________________

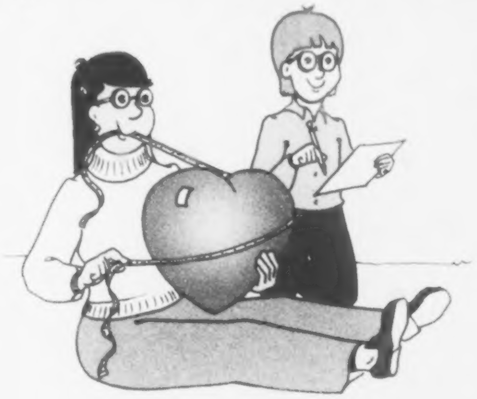
The healthy heart of an adult at rest beats about 72 times each minute, but the normal range is between 60 and 100. Physical exertion can elevate the pulse to a maximum of 220 beats, minus a person's age. But this rapid pulse could not be sustained for too long!

How do you think your heart rate might vary with exercise? Let's work in groups to conduct an experiment to help answer this question.

Directions: Work with your group to find the average heart rate while exercising.

RUNNING IN PLACE FOR ONE MINUTE		
Your Name	**Beats in 15 Seconds**	**Beats in 1 Minute**
AVERAGE		

JUMPING IN PLACE FOR ONE MINUTE		
Your Name	**Beats in 15 Seconds**	**Beats in 1 Minute**
AVERAGE		



The Sound of Your Heart

Names ______________________

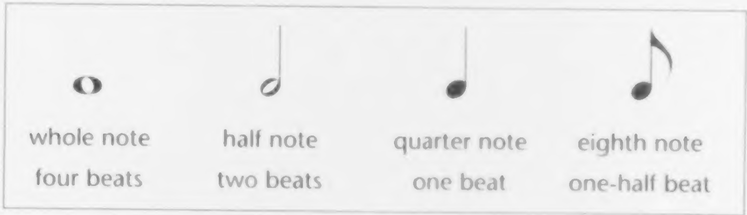
____

Date ______________________

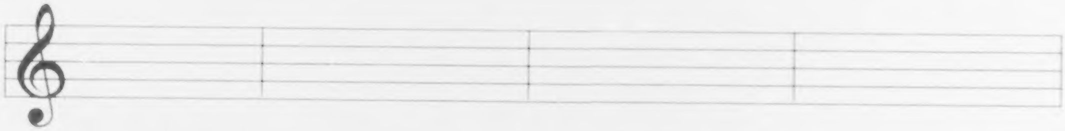
Class ______________________

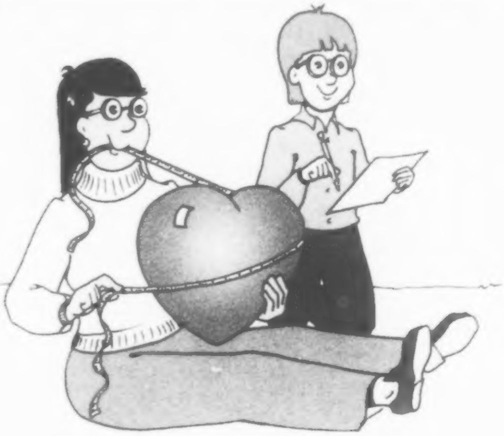
Listen to your heartbeat! It is steady and has a rhythm: one, two, three, four. In music, each measure is divided into fractional parts. These parts must add up to one whole. For example, in four-four time, all of the notes and rests add up to four and each quarter note counts for one beat. In this rhythm, a half note would get two beats and an eighth note would get one-half beat. Can you believe it? Fractions in music!

Let's examine these notes to see what they look like . . . .


whole note
four beats
half note
two beats
quarter note
one beat
eighth note
one-half beat

Write a song using your heartbeat as inspiration.





Grading Matrix

Names ______________________________

____

Date ______________________________

Class ______________________________

Criteria	4	3	2	1
Quality of heart rate experiment				
Quality of bathtub experiment				
Quality of exercise experiment				
Overall quality of project				

Comments:

The Thighbone's Connected to the . . .

MATHEMATICAL CONNECTIONS

measurement, data collection and analysis, percentages

INTELLIGENCES

logical/mathematical, bodily/kinesthetic, interpersonal, intrapersonal, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Skeletal system

CONCEPTS

Students will do the following:

1. Accurately measure the length of their thighbones and their total height using centimeters
2. Use a formula to compute their height based on the length of their thighbones
3. Calculate a difference
4. Find the percent of difference

MATERIALS NEEDED

meter sticks or tape measures; copy of "Calculate Your Height . . . " blackline for each group of students; calculators

PROCEDURES

Place students in groups of four and discuss the human skeletal system facts from the sheet. Make sure students understand how to measure the femur (thighbone.) It is best measured from the side of the leg (where the hip bends when the leg swings away from the body) to the top of the knee.

Discuss with students the difference between the formulas used with boys and girls. Does this mean that girls or boys have longer legs (in proportion to their body size)?

To find the percent of difference, students should do the following:

1. Subtract to find the difference
2. Divide the difference by the actual height
3. Multiply this decimal by 100 to convert it to a percentage

ASSESSMENT

1. Student products—Successful completion of blackline
2. Observation of students
3. Journal question: "The human body contains 206 bones. The skull, spine, and rib cage account for 80 of these. What percentage of the bones are in the skull, spine, and rib cage? What vital organs do these bones protect?"

Calculate Your Height Based on the Length of Your Thighbone

Names ____________________

____

Date ____________________

Class ____________________

The human skeletal system is an amazing piece of engineering. In most people, the thighbone is stronger, pound for pound, than reinforced concrete! When you walk at a quick pace, your thighbone resists an average of 1,200 pounds of pressure per square inch with every step. As a matter of fact, the 206 bones, which weigh about only 20 pounds, support muscles and organs which weigh many times more than they do.

One of the longest bones in our body is the femur, or thighbone. It is measured from the point where the hip bends to where the leg bends at the knee. If you place your fingers on your knee you can feel where the femur ends and the patella (or kneecap) begins. We can use the measurement of our femur to calculate our total height by using a formula. The formula is slightly different for boys and girls:

Boys: (The length of the thighbone (in cm) x 1.88) + 8.1 cm
Girls: (The length of the thighbone (in cm) x 1.95) + 7.3 cm

Use this formula to compute the heights of each person in your group. Complete all the information called for on the data collection table.

Student	Length of Thighbone	Height Using Appropriate Formula	Actual Height in cm	Difference	% of Difference $\frac{\text{difference}}{\text{actual height}} \times 100$
AVERAGE					

How close were your heights to the height predicted by the formula? Explain your answer.

____

____

Grading Matrix

Names ______________________________

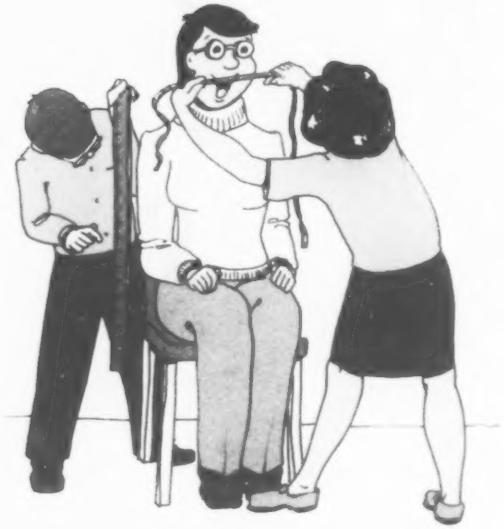
____

Date ______________________________

Class ______________________________

Criteria	4	3	2	1
Accuracy of computation				
Accuracy of measurements				
How well group worked together				

Comments:



How Long Is Your Digestive System?

MATHEMATICAL CONNECTIONS

measurement, data collections and analysis, mathematical connections

INTELLIGENCES

bodily/kinesthetic, logical/mathematical, interpersonal, intrapersonal, verbal/linguistic

OTHER CURRICULAR CONNECTIONS

Science: Digestive system

CONCEPTS

Students will do the following:

1. Work collaboratively to make connections between mathematics and science
2. Measure a distance using a nontraditional instrument and then interpret that distance using a more traditional method
3. Find mean lengths
4. Look for patterns between the length of their digestive system and total height

MATERIALS NEEDED

string (about six feet for each group); a copy of the "Sum of the Parts" blackline for each group; overhead transparency of class record sheet; meter sticks, yard sticks, or tape measures; calculators

PROCEDURES

Ask students how long they think their digestive systems are. Remind them that the digestive system starts at the mouth. Give students a chance to discuss this, then write their answers down so they can be referred to at a later time. Give groups of four copies of the "Sum of the Parts" blackline. Go over the procedures with them.

Have each group get the supplies they need and then begin collecting data. For the class record sheet, you will need the heights of each student in the class. Remind students to take a traditional measurement of their height in addition to the other nontraditional measurements.

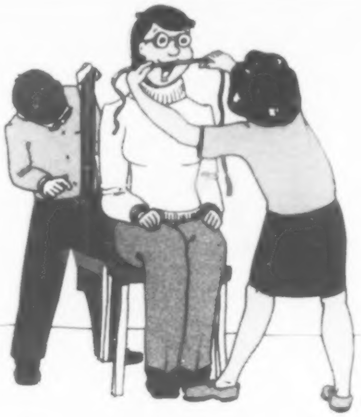
When individual groups have finished collecting data, have them write their mean lengths on the class record sheet as well as the mean heights of the individuals in their group. Place these in ratio form to see if there appears to be a ratio between the lengths of the digestive system and the heights of the students.

Variation: This activity makes very strong connections between mathematics and science. Other human systems can be examined and their relative size compared to the size of our digestive system.

ASSESSMENT

1. Observation of students
2. Student products
3. Grading matrix
4. Journal question: "What relationship did you find between the length of the digestive system and the mean

height of the students in your class? Do you think this number could be used to predict the height of a person if you knew the length of their digestive system? Why or why not?"



Sum of the Parts

Names ______________________________

____

Date ______________________________

Class ______________________________

Directions: Before you begin this activity, measure and record your heights.

Name ____________________ Height ____________________

Name ____________________ Height ____________________

Now measure each of the lengths asked for in the table below. Use a string to measure the lengths. Tie knots in the string to record the measurements. (Do not cut the string! Keep measuring from each knot.) Work with your partner. Help each other with the measurements and tying the knots. After you've measured each length, place that measurement in the correct place on the table. The total length of the system is the sum of each of the parts. Round your answer to the nearest centimeter. Find the mean length for each measurement.

Your Name	Mouth to back of jaw (mouth)	Back of jaw to bottom of sternum (esophagus)	Thumb to pinkie (stomach)	4 x your height (small intestines)	1 x your height (large intestines)	Total length of system
Mean Length						

Describe (analyze) your findings: ______________________________

____

____

____

____

____

____

____

____

Class Record Sheet

Names ______________________________

____

Date ______________________________

Class ______________________________

Group	Mean Length of Digestive System	Mean Height of Group Members	Ratio: $\frac{\text{Length of System}}{\text{Height}}$
MEAN			

Does there appear to be a pattern? Explain your answer. ______________________________

____

____

____

Grading Matrix

Names ______________________

____

Date ______________________

Class ______________________

Criteria	4	3	2	1
Completeness of measurements				
Correctness of computation				
Quality of written analysis				
How well group worked together				

Comments:

What Are Your Favorite Foods?

MATHEMATICAL CONNECTIONS

data collection, analysis, graphing, percentages

INTELLIGENCES

logical/mathematical, interpersonal, intrapersonal, verbal/linguistic, visual/spatial

OTHER CURRICULAR CONNECTIONS

Science: Digestive system

Social Studies: Foods from around the world. (Do other cultures have different food preferences? In some cultures, would sour or bitter foods be favorites rather than sweet and salty? Do some research on the foods of other lands.)

Language Arts: "My most memorable meal was . . ."

Literature: Read a book such as *Willy Wonka and the Chocolate Factory*.

CONCEPTS

Students will do the following:

1. Ask ten students to declare their most favorite food

2. Categorize each response and analyze the results
3. Draw a graph of their data

MATERIALS NEEDED

calculators; copies of "Food Survey" blackline; colored pencils or markers for graph

PROCEDURES

Discuss with students food preferences and their relationship to the society we live in. Do they think that all people would like hot dogs and hamburgers? Are there societies where these foods would be prohibited because of religious or other reasons? Chocolate ice cream may be a favorite in the United States; but would it be a favorite in Korea, where Kimchee (pickled cabbage) is a delicacy? Have the students brainstorm a list of foods that are sweet and a list of foods that are salty. Write the lists on the chalkboard.

Then, have students survey ten fellow students on what their favorite food is. Tell them to try to categorize the responses into four tastes. This may be difficult. However, since our taste buds only respond to four tastes (sweet, salty, sour, and bitter), it is logical to try to categorize the foods into these categories.

Students are then asked to set new criteria for graphing the information. They may want to combine the foods into categories such as hamburgers, hot dogs, pizza, etc. Give students the freedom to analyze and interpret their data. It is important for students to develop critical thinking skills. A graph has been supplied for students to design the visual representation of the data.

ASSESSMENT

1. Student products—Successful completion of project
2. Observation of students
3. Grading matrix

4. Journal question: "Describe the people you surveyed. Be sure to include their age, gender, etc. Do you think the results of your survey would have been different if the respondents were twenty years older? Why or why not?"

Food Survey

Names ______________________________

____

Date ______________________________

Class ______________________________

What are your favorite foods? Ice cream? Macaroni and cheese? Hamburgers? Salty potato chips? Each person has a different idea about what is the most delicious food!

But did you know that taste is a chemical sense that is activated when chemicals released from foods are carried to special sensors on your tongue? The tiny bumps, or papillae, on the tongue contain taste buds. An adult has about 10,000 taste buds! These taste buds respond to only four tastes: sweet, sour, salty, and bitter. Most people like sweet tastes and dislike bitter or sour foods. A bitter or sour taste can be a warning that the food is spoiled or poisonous.

Directions:

1. Take a survey of the favorite food of ten students. List them on the data collection sheet.
2. Analyze the data by dividing the foods into sweet, salty, sour, or bitter.
3. Draw a graph of their choices. Their choices may not fall into any of the categories.
4. Write a brief description of your data.

Food Chosen	Sweet	Salty	Sour	Bitter

What percent of the students you surveyed preferred sweet foods? ______________________________

What percent of the students you surveyed preferred salty foods? ______________________________

What percent of the students you surveyed preferred sour foods? ______________________________

What percent of the students you surveyed preferred bitter foods? ______________________________

Analyzing the Food Categories

Names ______________________________

____

Date ______________________________

Class ______________________________

Was it easy to place foods into the sweet and salty categories or did you find that most of people's favorites were in more than one category? Describe below what you feel might be a better way to categorize favorite foods than by using the sweet and salty distinctions.

____

____

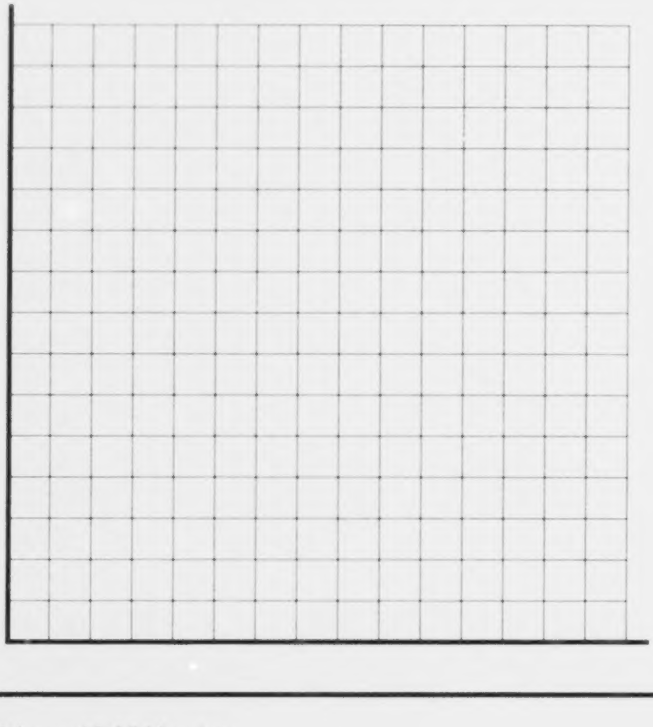
____

____

____

____

Organize the foods chosen by the people in your survey in a better way. Then design a graph to display the data. Be sure to label the axes and title the graph.



Grading Matrix

Names ______________________________

____

Date ______________________________

Class ______________________________

Criteria	4	3	2	1
Quality of data collection				
Interpretation of data				
Design of graph				
Quality of written responses				
Comments:				

Additional Reading

Lambourne, M. 1991. *Inside story*. Brookfield, Conn.: Millbrook Press.

With a sense of humor, this book describes the workings of the human body, covering the major organ systems and health tips.

Packard, M. 1985. *From head to toe: How your body works*. New York: Julian Messner.

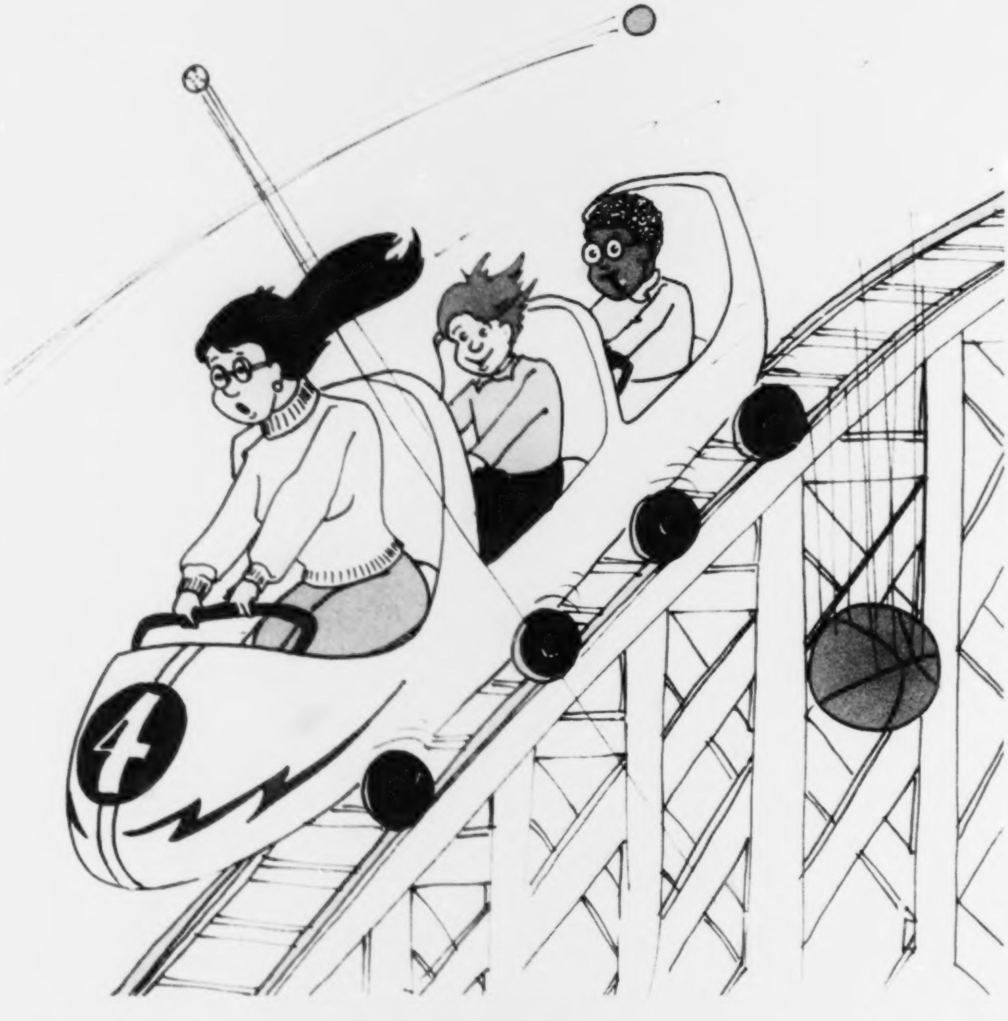
This book is a great reference book for youngsters. It describes the different systems of the human body, including the circulatory, digestive, nervous, and reproductive systems, and how they work.

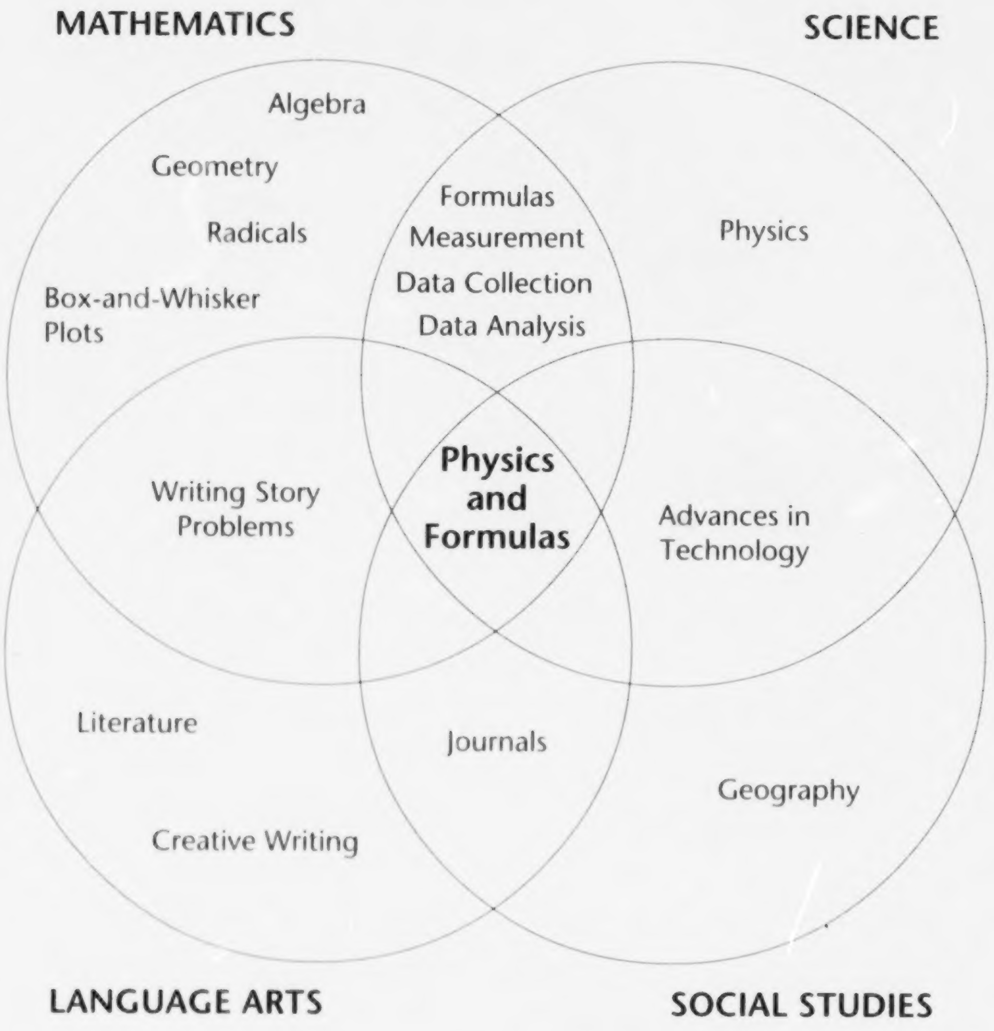
Reader's Digest Association. 1987. *ABC's of the human body*. Edited by A. E. Guiness. Pleasantville, N. Y.: The Reader's Digest Association, Inc.

A comprehensive look at the systems of the human body. A wonderful reference book.

CHAPTER 8

Physics and Formulas




MATHEMATICS
SCIENCE
Algebra
Geometry
Radicals
Box-and-Whisker Plots
Formulas
Measurement
Data Collection
Data Analysis
Physics
Writing Story Problems
Physics and Formulas
Advances in Technology
Literature
Journals
Geography
Creative Writing
LANGUAGE ARTS
SOCIAL STUDIES

CHAPTER 8

Physics and Formulas

> *No human inquiry can be called science unless it pursues its path through mathematical exposition and demonstration.*
>
> —Leonardo da Vinci

Mathematics is used to explain the laws of science. Scientists value mathematics because it is an essential part of the discovery process. In *Project 2061: Science for All Americans* (AAAS 1989), this alliance is described as "having a long history, dating back many centuries. Science provides mathematics with interesting problems to investigate, and mathematics provides science with powerful tools to use in analyzing data" (p. 34).

This chapter is rich in interdisciplinary experiences for students. The unit is written as a shared thematic experience and will be supported by a traditional middle school schedule.

Mathematics uses abstract symbols as its language. For this reason, the language of mathematics is universal. However, it is also difficult for students to comprehend. Many middle school students are still very concrete in their thinking patterns and are unable to understand the real meaning of abstract formulas such as $V= {}^4/_3\ \pi r^3$ or $d= {}^1/_2\ (32)t^2$. The mathematical activities that are part of these shared thematic experiences afford students the opportunity to apply these concepts, making them more real.

The first formula is used to find the volume of a sphere. We use this formula to answer the question, "Will this ball sink or float?" In what appears to be a complicated experiment, students discover the density of various sports balls while using formulas and variables.

The second formula describes the distance an object on Earth falls in a measured amount of time. In the lesson "Roller Coasters: How Fast Are We Falling?," we know how far we are traveling because we are given the vertical drop. How long it will take us to get to the bottom can be computed using a formula.

But, where are these roller coasters? Making connections to social studies is a natural! By locating the states where the amusement parks are located, students are making genuine connections between the math lesson and geography. Perhaps some of them have visited these parks and could relate their experiences to the class.

The third lesson, "Roller Coasters and G-Force," looks at roller coasters from another perspective. Students investigate the speed of the roller coaster and its curves to compute the amount of g-force on its riders.

Language arts is interwoven through the curriculum as well. In mathematics class, students can write story problems related to their investigation; in science class, they can keep journals of their experiments; and in language arts class, there are numerous books to be read and creative writing assignments to be written. Selected readings for each unit are at the end of the chapter. Some of the books are nonfiction and provide additional information about the lesson. Others are are fictional tales related to the unit.

Sports Balls and Density

MATHEMATICAL CONNECTIONS

data collection, measurement, geometry, volume, algebra concepts, collaborative learning

INTELLIGENCES

logical/mathematical, visual/spatial, verbal/linguistic, interpersonal, bodily/kinesthetic

OTHER CURRICULA CONNECTIONS

Science: Density, data collection and analysis

Social Studies: Games and sports of other nations

Language Arts: Creative writing, book reports

Literature: Selected readings about sports figures—fiction and biographies

CONCEPTS

Students will do the following:

1. Find the mass of sports balls
2. Find the volume of sports balls

3. Substitute calculated measurements into the density formula
4. Relate the density of a ball to its ability to sink or float

MATERIALS NEEDED

sports balls; tape measures; scales; copies of "Finding the Density of a Ball" blackline for each group of students

PROCEDURES

Hold up the tennis ball and ask the class, "Do you think this ball would sink or float in water?" Most students will probably agree that the tennis ball would float. Then hold up the baseball and ask the same question. There should be more of a controversy about this one!

The density of an object determines whether it will float or sink; we need to find the density of each of the sports balls. The formula for finding density is:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

The mass is found by weighing each ball. To find the volume, we use the formula: $^4/_3\,\pi r^3$

If students measure the circumference and divide by π, they will have the diameter of the ball; by dividing that by 2, they will have the radius. Now students have the measurements they need to compute the density.

ASSESSMENT

1. Student products
2. Observation of students
3. Grading matrix
4. Journal question: "Explain how you used π to find the density of a sports ball."

Finding the Density of a Ball

Names ______________________________

____

Date ______________________________

Class ______________________________

If the ball you are playing with falls into the water, do you think it will sink or float? Do you think it matters what kind of ball it is? Do you think a soccer ball will float? A baseball? A golf ball? To answer these questions, you need to know the density of the ball. Density is the relationship between the volume and mass of an object. The formula for finding the density of an object is:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Finding the density of a sports ball requires us to find the following:

1. The mass of the ball (we weigh it using a scale)
2. The volume of the ball (the formula for finding the volume of a sphere is $\frac{4}{3}\pi r^3$)
3. The circumference of the ball to help us compute the radius
4. The radius in the volume formula in step 2

Sound complicated? Well, just take it one step at a time!

Consider this: If the circumference = $\pi(2r)$, then $2r = \frac{\text{circumference}}{\pi}$. Our strategy will be the following:

1. Find the circumference of each ball.
2. Divide that measurement by π (~3.14)—we now know the diameter of the ball.
3. Divide the diameter in half to get the radius.

Let's work together to find the density of a tennis ball:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Place your measurements in the table below:

Ball (type)	**Mass** in grams	**Radius** $\left(\frac{1}{2}\right)\frac{C}{\pi}$	**Volume** $\frac{4}{3}\pi r^3$	**Density** $\frac{\text{mass}}{\text{volume}}$

Sports Balls Density Table

Names ______________________

____

Date ______________________

Class ______________________

Use the information on the previous page to find the density of the various sports balls on this page

Ball	**Mass** in grams	**Radius** $\left(\frac{1}{2}\right)\frac{C}{\pi}$	**Volume** $\frac{4}{3}\pi r^3$	**Density** $\frac{\text{mass}}{\text{volume}}$
Softball				
Soccer Ball				
Volleyball				
Basketball				
Baseball				
Golf Ball				
Ping-Pong Ball				
Cricket Ball				

Which balls have a density > 1? ______________________

Which balls have a density < 1? ______________________

Which of these balls do you think will float? ______________________

____

____

Which do you think will sink? ______________________

____

Grading Matrix

Names ______________________

____

Date ______________________

Class ______________________

Criteria	4	3	2	1
Accuracy of measurement				
Accuracy of computation				
Quality of written responses				
How well students worked together				

Comments:

Roller Coasters and Acceleration

MATHEMATICAL CONNECTIONS

substitution for a variable, algebra, medians, box-and-whisker plots, radicals

INTELLIGENCES

logical/mathematical, visual/spatial, intrapersonal

OTHER CURRICULAR CONNECTIONS

Science: Physics, solving formulas

Social Studies: International games (Olympics)

Language Arts: Creative writing, literature

CONCEPTS

Students will do the following:

1. Substitute distance into the acceleration formula to calculate the time it takes to get to the bottom of a vertical drop of a roller coaster
2. Find the square root of a number
3. Learn to design a box-and-whisker plot
4. Analyze the data presented on a box-and-whisker plot

MATERIALS NEEDED

calculators (essential); blacklines from this section for each student

PROCEDURES

Discuss the acceleration formula with students. The distance an object falls on Earth = $\frac{1}{2}(32)t^2$; $d = 16t^2$; Solving for t:

$$t = \sqrt{\frac{d}{16}}$$

The second activity uses the data from the roller coasters to form a box-and-whisker plot. This is an interesting graphic representation. Each section contains the same amount of data (regardless of the size). The smaller the area, the smaller the range of the data within that quadrant.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "Design a box-and-whisker plot using the following data."

The Tallest Buildings	
Sears Tower	443 meters
World Trade Center	411 meters
Empire State Building	381 meters
Standard Oil	346 meters
John Hancock	343 meters
Chrysler Bldg.	319 meters
60 Wall Tower	290 meters
First Canadian	289 meters
40 Wall Tower	282 meters
Bank of Manhattan	274 meters

How Fast Are We Falling?

Names ______________________________

____

Date ______________________________

Class ______________________________

On Earth, objects accelerate at a speed of $32 \frac{ft}{sec}$. The distance something travels can be computed by using this formula:

distance (d) = $\frac{1}{2}$ Acceleration (A) x time $(t)^2$

Since A=32, we can rewrite the formula in a simpler way: $d = 16t^2$

The formula you will use in the table has been rewritten to solve for time (t).

Let's solve for the Viper: $t = \sqrt{\frac{d}{16}} = \sqrt{\frac{188}{16}} \approx 3.4$ seconds

	Coaster Name	**Amusement Park**	**Vertical Drop (d)**	**Falling Time** $t=\sqrt{\frac{d}{16}}$
1.	Viper	Six Flags Magic Mountain	188 feet	
2.	Batman: The Ride	Six Flags Magic Mountain	105 feet	
3.	The Texas Giant	Six Flags Over Texas	137 feet	
4.	Magnum XL-200	Cedar Point	205 feet	
5.	Mean Streak	Cedar Point	161 feet	
6.	Raptor	Cedar Point	137 feet	
7.	Cyclone	Astroland, Coney Island	85 feet	
8.	The Beast	Paramount's Kings Island	135 feet	
9.	Top Gun	Paramount's Great America	100 feet	
10.	Kumba	Busch Gardens Tampa	143 feet	
11.	Drachen Fire	Busch Gardens Williamsburg	150 feet	
12.	The Big Bad Wolf	Busch Gardens Williamsburg	100 feet	
13.	Thunderbolt	Kennywood	90 feet	
14.	The Steel Phantom	Kennywood	225 feet	

Box-and-Whisker Plots

Names

Date

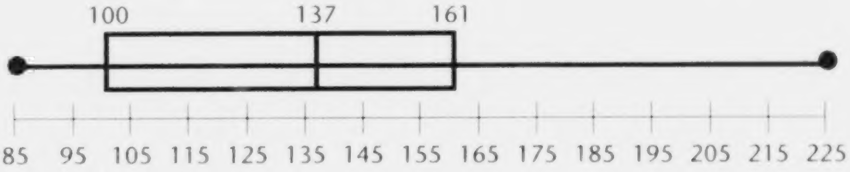
Class

Let's organize the data from the table of roller coasters into a box-and-whisker plot. To design this graph, we must first organize the data from least to greatest.

85 90 100 100 105 135 137 137 143 150 161 188 205 225

Steps

1. Find the median height: this is the height that is in the middle. Since there are fourteen roller coasters, there are two heights in the middle. Both of them are the same—137.
2. Next, find the median of the lower half (those from 85 feet to 137 feet). The median of this lower quartile is 100.
3. Now find the median of the upper half (those from 137 to 225 feet). The median of the upper quartile is 161.
4. The lowest and tallest roller coaster become the whiskers. This is what the box-and-whisker plot will look like:



Use the box-and-whisker plot to answer these questions:

1. What percent of the data falls between the lower whisker and lower quartile?
2. What percent of the data falls in the lower quartile?
3. What percent of the data falls in the upper quartile?
4. What percent of the data falls within the box?
5. What does the whisker represent?
6. Although the same number of roller coasters are represented in each quartile, the sizes of the quartiles are different. How would you explain this difference?

Where Are the Roller Coasters?

Names ______________________________

____

Date ______________________________

Class ______________________________

Roller Coaster Locations

	Coaster Name	Amusement Park	Location	Area of the Country
1.	Viper	Six Flags Magic Mountain	California	
2.	Batman: The Ride	Six Flags Magic Mountain	California	
3.	The Texas Giant	Six Flags Over Texas	Texas	
4.	Magnum XL-200	Cedar Point	Ohio	
5.	Mean Streak	Cedar Point	Ohio	
6.	Raptor	Cedar Point	Ohio	
7.	Cyclone	Astroland, Coney Island	New York	
8.	The Beast	Paramount's Kings Island	Ohio	
9.	Top Gun	Paramount's Great America	California	
10.	Kumba	Busch Gardens Tampa	Florida	
11.	Drachen Fire	Busch Gardens Williamsburg	Virginia	
12.	The Big Bad Wolf	Busch Gardens Williamsburg	Virginia	
13.	Thunderbolt	Kennywood	Pennsylvania	
14.	The Steel Phantom	Kennywood	Pennsylvania	

(Continued on next page)

Where Are the Roller Coasters? (Continued)

Find the coasters listed on the table (on page 200) on the map below.

What percent are located in the East? ______________________________

In the Midwest? ______________________________

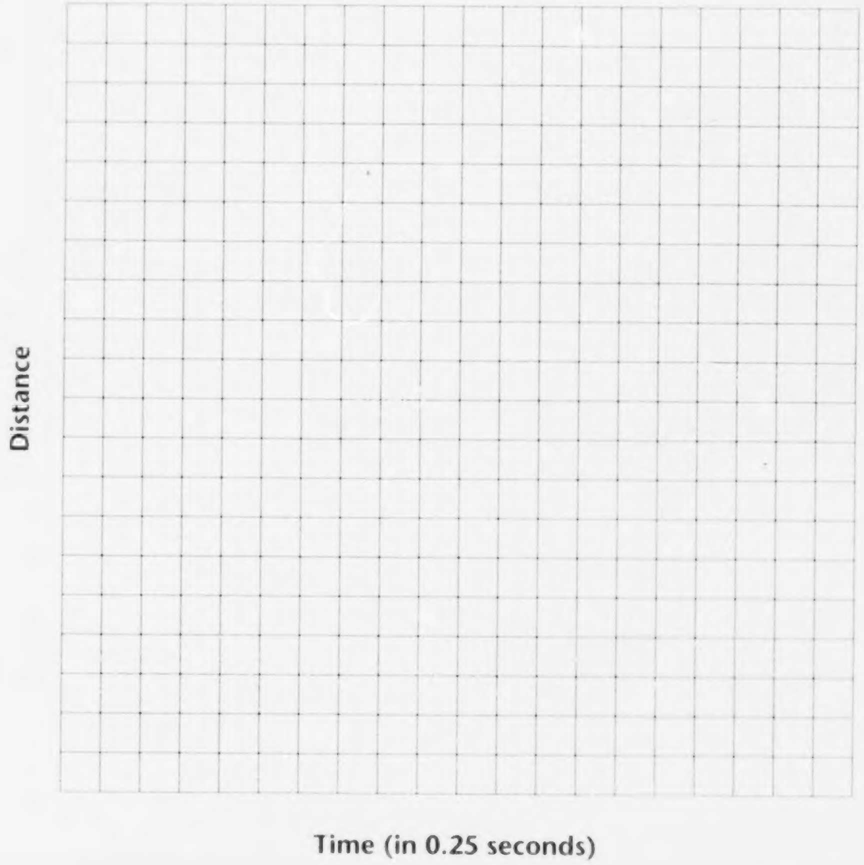
In the South? ______________________________

In the West? ______________________________

Roller Coaster Grid

Names ______________________________
____
Date ______________________________
Class ______________________________

Use the grid below to graph the relationship of one of the roller coasters between the time it takes you to fall and the distance you travel. Remember, the formula is: $D = 16t^2$. Example: To calculate how far you drop after one second: $D = 16(1)^2 = 16$ feet. How far would you fall after 2 seconds? 3 seconds? Remember you stop when you hit the ground! (That will be the vertical drop of the roller coaster.)



Grading Matrix

Names ______________________

____

Date ______________________

Class ______________________

Criteria	**4**	**3**	**2**	**1**
Accuracy of computation				
Quality of written responses				
Overall quality of project				

Comments:

Roller Coasters and G-Force

MATHEMATICAL CONNECTIONS

substitution for a variable, decimals, data collection, problem solving

INTELLIGENCES

logical/mathematical, visual/spatial, intrapersonal

OTHER CURRICULAR CONNECTIONS

Science: Physics

Language Arts: Journal writing

CONCEPTS

Students will do the following:

1. Calculate weight based on the force of g's on the body
2. Understand the relationship between the radius of the curve of a roller coaster and its speed to the g-force created
3. Problem solve maximum speeds for safe g-forces
4. Problem solve curve tightness based on the speed of a car

MATERIALS NEEDED

metric rulers; copies of blacklines; calculators

PROCEDURES

Discuss with the students what g-force represents and work through some of the problems with them. It is believed that most people can tolerate 4.5 g's for a fraction of a second but prolonged exposure at that pressure or higher can cause riders to black out. For this reason, most roller coasters try to maintain a g-force of not more than 3.5.

The speed of a car is linked with the tightness or radius of the curve. Both of these variables increase the g-force and so they need to be balanced to maintain safe levels. This experiment asks students to work collaboratively to design a roller coaster with five curves of varying radii and speeds.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "The formula for finding g-force is:

$$\text{G-Force} = \frac{(\text{speed of car})^2 \text{ (in ft/sec)}}{32 \times \text{radius (in ft)}}$$

Explain why the g-force becomes less as the radius of the circle increases."

Calculating G-Force

Names ______________________________

____

Date ______________________________

Class ______________________________

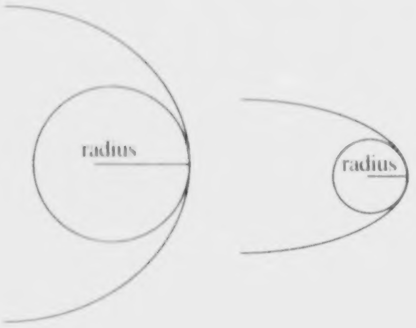
Do you know why the first hill on a roller coaster is always the highest? Because roller coasters don't run with engines or electric motors! They operate on gravity. And the same gravity that gives riders chills and thrills puts pressure on their bodies. This force is called g-force (gravity force). The pressure a person normally feels is 1 g—the force of gravity. With a pressure of 2 g's, a person feels twice the normal gravitational pull. A 120-pound person would show a weight of 240 pounds with this kind of pressure on his or her body. If you were under a 0.5 g of force, you would show half your normal weight on a scale.

Write your weight here: ______________________________

What would a scale indicate if you were under a g-force of 0.75? ______________

If the scale showed a weight of 321 and you were under a g-force of 3, how much would you weigh under normal g-force? ______________________________

It is the g-forces on roller coasters that cause that "thrilling" feeling in the pit of your stomach. It is believed that a force of 3.5 is all right, but anything much higher than that can be dangerous! G-force is determined by two factors: (1) how fast the car is going, and (2) the amount (or tightness) of the curve in the track. To keep the g-forces at safe levels, there must be a balance between speed and tightness of turns.



A small circle causes the curve to be very tight. A roller coaster would need to be slowed down to keep the g-forces at a safe level.

On the other hand, a larger circle makes for a gentle curve. The car can be speeded up and still have safe g-forces.

We can use this formula to find g-forces:

$$\text{G-Force} = \frac{(\text{speed of car})^2 \ (\text{in } \frac{\text{ft}}{\text{sec}})}{32 \times \text{radius (in ft)}}$$

G-Force and Curves

Names ______________________________

____

Date ______________________________

Class ______________________________

Let's look at how this formula can be used to calculate g-force: $\dfrac{(\text{speed of car})^2\ (\text{in } \frac{\text{ft}}{\text{sec}})}{32 \times \text{radius (in ft)}}$

Remember that 32 represents the speed an object falls—32 feet per second. A roller coaster car is rounding a curve at a speed of 55 feet per second. If the radius of the curve is 35 feet:

$$\text{G-Force} = \frac{55^2}{32 \times 35} = 2.7$$

Your Problem

Your group is designing a roller coaster with lots of curves and hills and valleys! Remembering that g-forces of 3.5 or less are safe, indicate the radius of each of your curves and the speed of the car at that curve. You can have g-forces of not more than 3.5. Use the table below for the data. You can give each of your curves a name, indicate the radius of each of the curves and the speed of the car at that curve. Then compute the g-force at that curve:

Name of Curve	**Radius of Curve**	**Speed of Car**	**G-Force =** $\dfrac{(\text{speed of car})^2\ (\text{in } \frac{\text{ft}}{\text{sec}})}{32 \times \text{radius (in ft)}}$

Grading Matrix

Names ______________________________

____

Date ______________________________

Class ______________________________

Criteria	4	3	2	1
Accuracy of computation				
Quality of written responses				
Overall quality of project				
Comments:				

Additional Reading

Sports

Allen, A. B. 1975. *The tennis menace*. Chicago: A. Whitman.

The story of Alex Wexler's summer, including tennis tournaments and an interesting social life.

Devaney, J. 1967. *Great Olympic champions*. New York: Putnam.

A biography that gives brief profiles of seventeen Olympic gold medalists, including Jim Thorpe, Paavo Nurmi, Johnny Weismuller, Babe Didrikson, Jesse Owens, Bob Mathias, Bill Russell, and Billy Mills. Some of these champions even used sports balls.

Finlayson, A. 1970. *Champions at bat: Three power hitters*. Champaign, Ill.: Garrard Publishing.

An interesting biography of three of baseball's "power hitters": Rogers Hornsby, Joe DiMaggio, and Ted Williams.

Iverson, C. 1990. *There are golf balls on the moon: And other facts and curiosities*. Minneapolis: Lerner Publications.

This book provides an interesting look at the history of sports and the athletes who participate in them.

Whitney, A. 1977. *Sports & games the Indians gave us*. New York: McKay.

A look at the sports and games of the Native Americans of North America. There are detailed step-by-step instructions for making the gaming equipment.

There are many biographies of famous athletes. Students should be encouraged to choose one that represents a favorite sport.

Roller Coasters

Carlson, N. L. 1982. *Harriet and the roller coaster.* Minneapolis: Carolrhoda Books.

Harriet is challenged by her friend George to ride a frightening roller coaster. When she accepts the challenge, she finds out just how brave she is.

Duffy, B. 1994. *Coaster.* New York: Viking.

While secretly building a roller coaster in the woods, twelve-year-old Hart tries to come to terms with his parents' divorce and his mother's new beau.

Lampton, C. 1991. *Bathtubs, slides, roller coaster rails: Simple machines that are really inclined planes.* Brookfield, Conn.: Millbrook Press.

A Gateway book that describes simple machines, inclined planes, and has some fascinating science experiments.

Oleksy, W. G. 1982. *Quacky and the haunted amusement park.* New York: McGraw Hill.

Quacky's dog, Puddles, is the victim of dognappers. What does Quacky do? He follows the only clue he has—the sound of a barking dog in an abandoned amusement park!

Van Steenwyk, E. 1983. *Behind the scenes at the amusement park.* Niles, Ill.: Whitman.

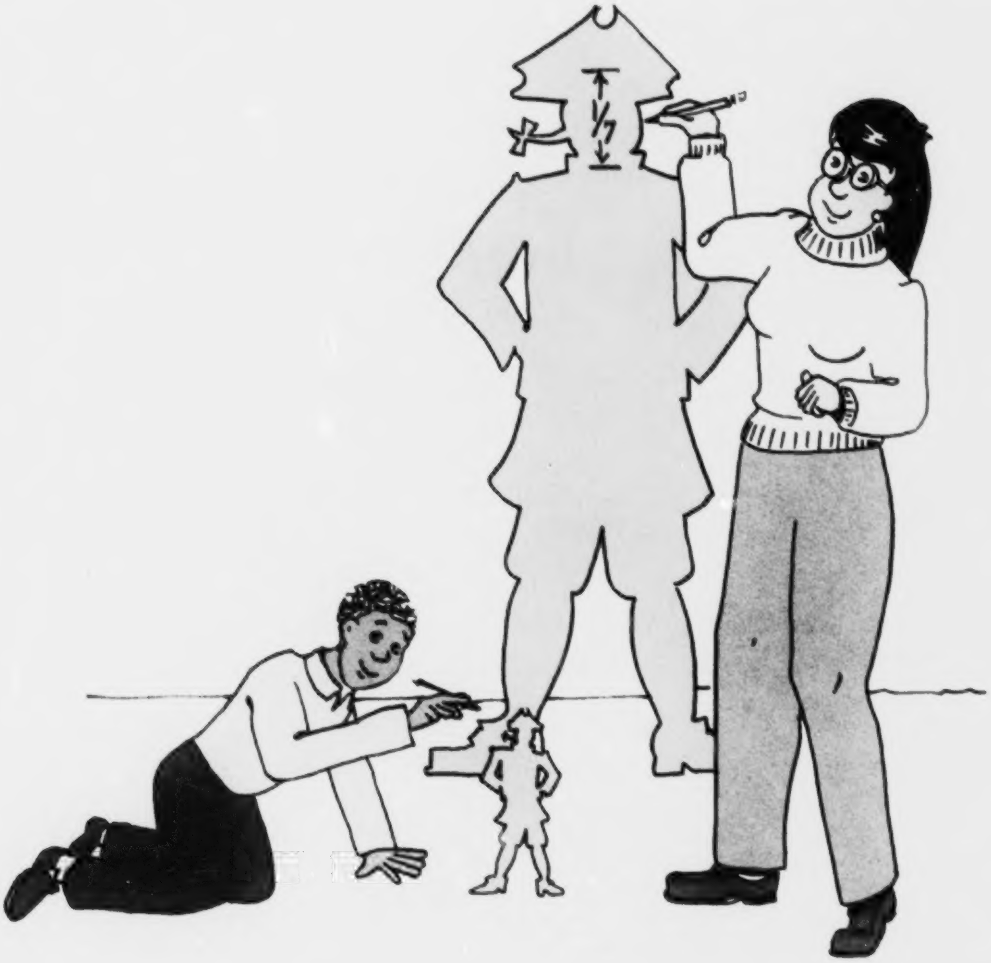
Everything you ever wanted to know about the operation of an amusement park from the safety and maintenance of the rides (including the roller coaster) to keeping the park clean. This book also describes career opportunities in amusement parks.

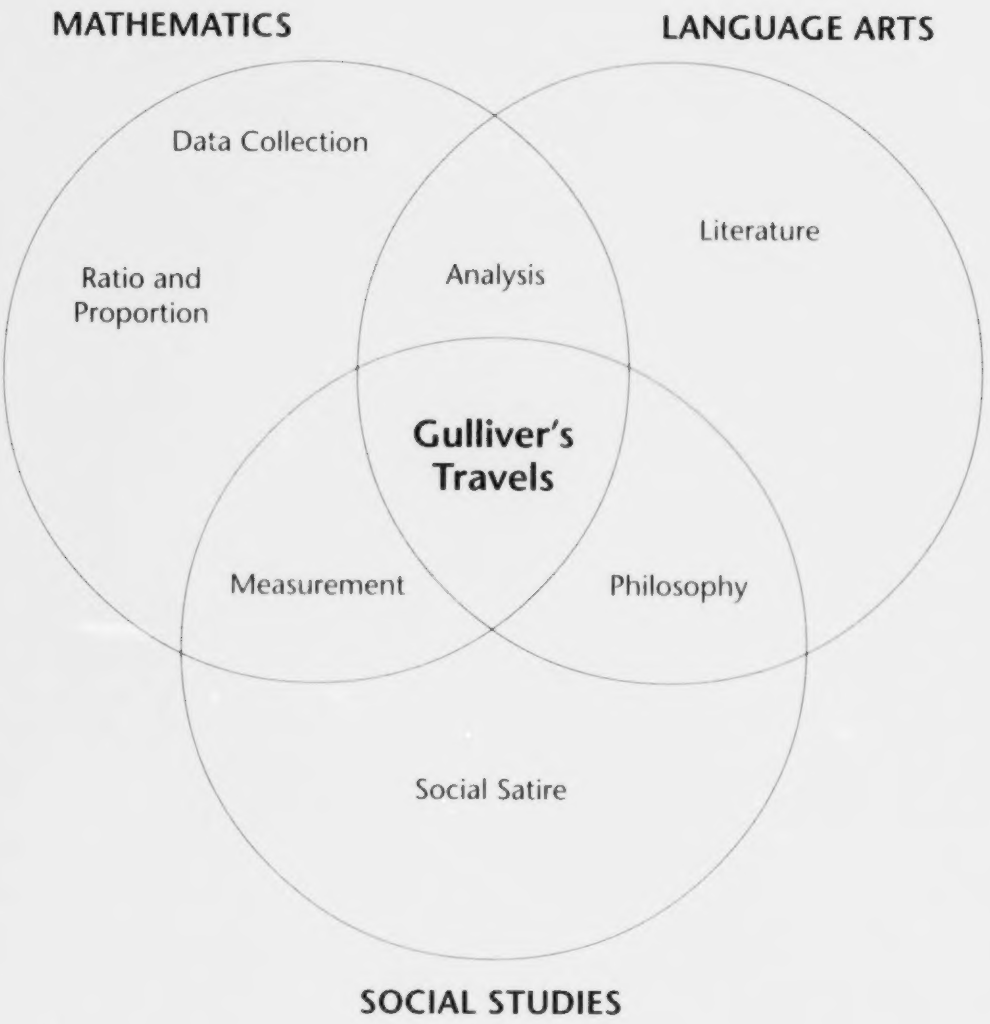
Wallenstein, B. 1982. *Roller Coaster Kid and other poems.* New York: Crowell.

A delightful book of children's poetry to enhance the study of roller coasters.

CHAPTER 9

Gulliver's Travels




MATHEMATICS
LANGUAGE ARTS
Data Collection
Literature
Ratio and Proportion
Analysis
Gulliver's Travels
Measurement
Philosophy
Social Satire
SOCIAL STUDIES

CHAPTER 9

Gulliver's Travels

Literary satire has been used as a form of protest throughout history. Jonathan Swift's *Gulliver's Travels* is a powerful satire of society that combines the tale of a fantastic voyage with a serious philosophical and social message. The book can help integrate topics of interest in social studies, language arts, and mathematics classes.

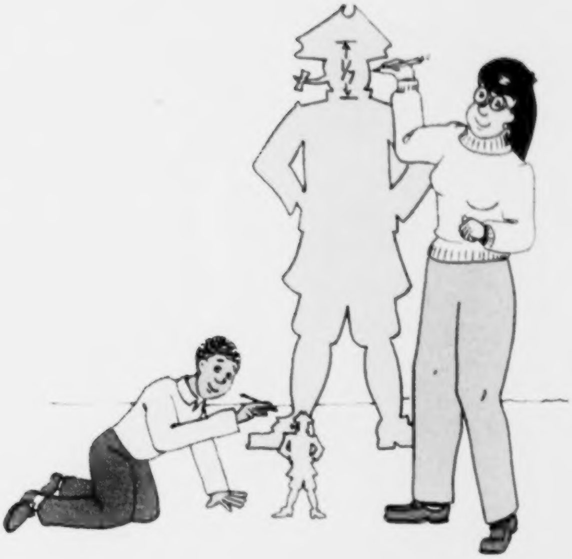
Swift was born in Dublin, Ireland, on November 30, 1667. Ordained as an Anglican priest, Swift wrote *Gulliver's Travels* while serving as dean of St. Patrick's Cathedral in Dublin. Published in 1726, the book's satire was directed at the inequities of the English Whigs, and Swift became a hero in his native Ireland.

In social studies, students can examine how social satire has been used to foster change. Are political cartoons a form of twentieth-century satire? How are they used to bring our attention to social issues?

In language arts, students can write a satirical piece that pokes fun at something they disagree with, or they can write about how they would feel if they were trying to survive in the land of Lilliput or Brobdingnag.

In mathematics, *Gulliver's Travels* provides the basis for a problem-solving activity that asks students to draw a Lilliputian, knowing only that they are six inches tall! Using measuring, averages, and conversion ratios, students find the length of a Lilliputian's arm, the size of its head, the length from its head to its waist, the size of its hands, and the length of its legs. Using these measurements, they can draw a full-size portrait of this little person.

This activity highlights Gulliver's stop at the land of Lilliput. His second voyage takes him to the land of Brobdingnag, where the people are sixty feet tall—one hundred twenty times the size of a Lilliputian. In this land of giants, grass grows to a height of twenty feet, a man's stride is ten yards long, and a small cup holds about three gallons of liquid. These statistics could be the beginning of interesting follow-up activities that focus on length and volume.



Traveling to Lilliput

MATHEMATICAL CONNECTIONS

measurement, data collection and analysis, scale drawing, ratio and proportion

INTELLIGENCES

logical/mathematical, verbal/linguistic, visual/spatial, bodily/kinesthetic, interpersonal

OTHER CURRICULAR CONNECTIONS

Literature: *Gulliver's Travels*

Social Studies: Satire as a form of social protest

Language Arts: "Swift used satire as a form of social protest. Think of something in today's society that you disagree with and write a satirical piece that pokes fun at it."

CONCEPTS

Students will do the following:

1. Measure their height and use it to find a conversion ratio
2. Use the conversion ratio to approximate the size of body parts of Lilliputians

3. Draw a picture to scale

MATERIALS NEEDED

tape measures, rulers, and/or yardsticks; calculators; copies of blacklines in this section; markers, colored pencils, or crayons

PROCEDURES

With the students, read the excerpt from *Gulliver's Travels* on the "How Little Were the Lilliputians?" blackline. Discuss that Gulliver had washed up on the beach and was captured by tiny people called Lilliputians. Gulliver tells of this experience while tied to the ground with thousands of little stakes and rope. The Lilliputians are walking on his body when he awakens. Ask the students, "If a person is only six inches tall, how big do you think his head would be? His arms? His legs?"

Explain what the conversion ratio represents and how it can be used to find the size of a Lilliputian's body parts. Give students time to collect their data and draw their Lilliputian. Pictures can be displayed around the room.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "What problems might you face as a 'big' person in the land of 'little people'? What advantages might there be?"

How Little Were the Lilliputians?

Names ______________________________

____

Date ______________________________

Class ______________________________

Gulliver's Travels by Jonathan Swift is a fantastic tale of the voyages of Lemuel Gulliver, a ship's surgeon who was shipwrecked. When he washes up on the beach, the residents of Lilliput become very alarmed by this giant because they are only 6 inches tall. Swift describes Gulliver's reactions in the following way:

> I felt something alive moving on my left leg, which advancing gently forward over my chest, came almost up to my chin; when bending my eyes downwards as much as I could, I perceived it to be a human creature not six inches high, with a bow and arrow in his hands, and a quiver at his back. . . . I roared so loud that they all ran back in a fright; and some of them, as I was afterwards told, were hurt with the falls they got by leaping from my sides upon the ground.

It would be interesting to figure out how long a Lilliputian's arms were, how long their fingers were, or how big their heads were! We can do this by using a conversion ratio computed by using their heights and our heights!

$$\text{Conversion ratio} = \frac{\text{Lilliputian's Height (6 in)}}{\text{Average Group Height (in)}}$$

Use the table below to enter your data and find the conversion ratio for your group.

The conversion ratio for our group is ______________________________

Name	**Height in Inches**	**Ratio = $\frac{\text{6 in}}{\text{your height}}$**	**Decimal**
MEAN			

Using Your Conversion Ratio

Names ____________________

____

Date ____________________

Class ____________________

Directions: Use this ratio to compute the size of other parts of the Lilliputians. For example, after you find the average length of your group's arms (shoulder to tip of finger) you can multiply that measurement by the conversion factor, and you will have the length of the Lilliputian's arm.

MEASUREMENT	Person 1	Person 2	Person 3	Person 4	Average	Average × Conversion Ratio	Size of Lilliputian
Length of Arm (from shoulder to tip of finger)							
Circumference of Head							
Length from Head to Waist							
Size of Hand							
Length of Leg							

Draw a Lilliputian

Names ______________________________

Date ______________________________

Class ______________________________

Use this graph to draw a picture of a Lilliputian. Use the measurements on the previous page as your guide. Each square is $\frac{1}{4}$ inch.

Grading Matrix

Names ______________________

____

Date ______________________

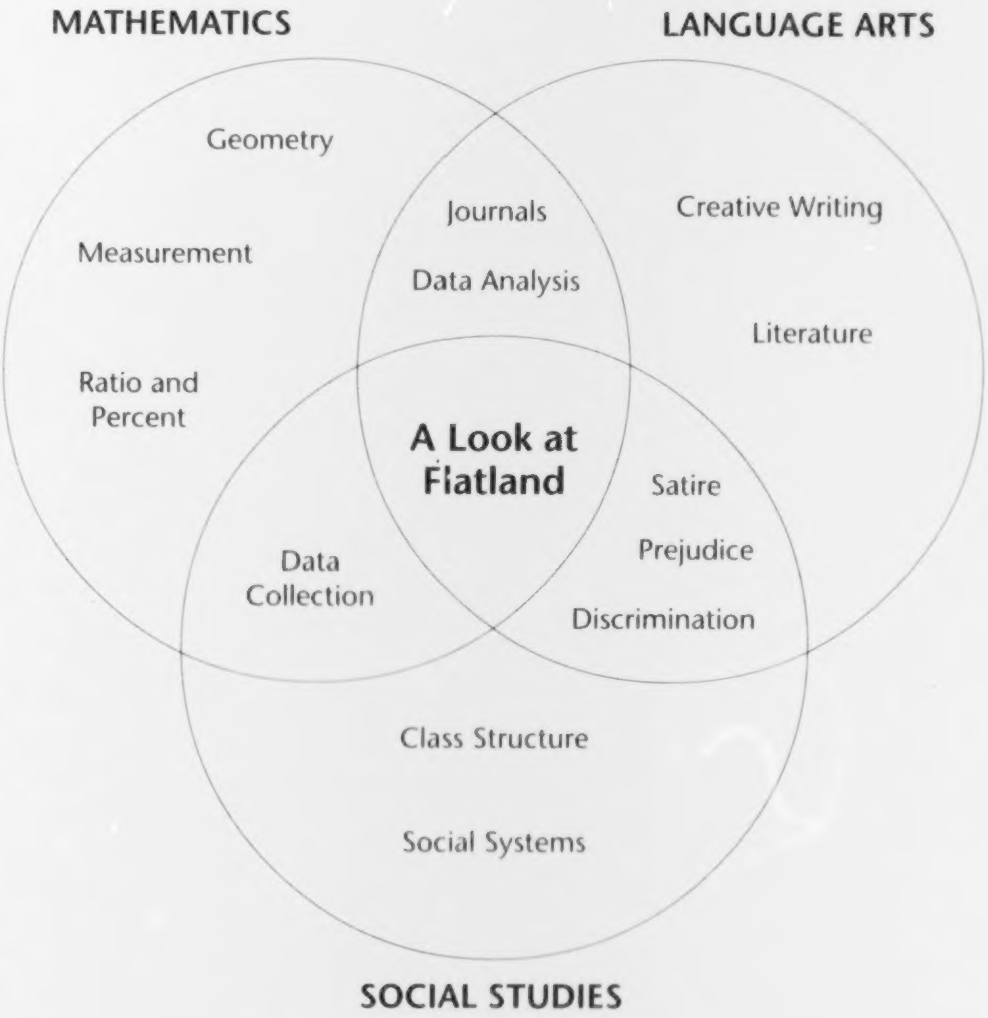
Class ______________________

Criteria	**4**	**3**	**2**	**1**
Accuracy of computation				
Quality of written responses				
Overall quality of project				

Comments:

CHAPTER 10

In Two Dimensions


MATHEMATICS
LANGUAGE ARTS
Geometry
Measurement
Ratio and Percent
Journals
Data Analysis
Creative Writing
Literature
A Look at Flatland
Satire
Prejudice
Discrimination
Data Collection
Class Structure
Social Systems
SOCIAL STUDIES

CHAPTER 10

In Two Dimensions

The world described by Edwin Abbott in *Flatland* is one of rigid class distinctions, suffocating bigotry, and the social customs of a narrow-minded society. In Flatland, there are only two dimensions—length and width. The inhabitants are geometric shapes—the lowest class, lines, are women. The soldiers and police are violent, triangular men who can cause great damage with their very acute angles. The higher classes are multiangled, regular polygons. The more sides and angles a figure has, the higher its social class. The circle is the highest in Flatland's social order.

Flatland is told by a middle-class square who has been made aware of the three-dimensional world, and is, therefore, cognizant of the peculiar predicament his world's inhabitants are in. How do you know what shape you are looking at if you do not have the privilege of looking down on it from space? A penny viewed from a two-dimensional perspective appears to be a line.

Abbott's *Flatland* is rich in ideas that help make middle school connections. In social studies, students can examine class structures and social systems. In the language arts curriculum, the mathematical prejudice of *Flatland* can be connected to other literature that exposes intolerance and bigotry.

Flatland is a study of dimensions: We see one dimension from the viewpoint of a Pointlander, two dimensions from the viewpoint of a Flatlander, and three dimensions from the viewpoint of a Spacelander. As these dimensions confront each other, they are not only incapable of understanding the limitations of their view but are enraged when asked to see beyond them. What an interesting look at human nature. Can a person blind from birth truly understand color? If we cannot actually count the grains of sand on a beach, do we believe an approximation of their number?

This unit has been designed to allow teachers of social studies, language arts, and mathematics to collaborate to give their students a unique interdisciplinary experience. The mathematical experiments give students an opportunity to identify geometric shapes through the view of a Flatlander and experience a two-dimensional world. Every effort should be made to keep your students on a level plane. Remember, do we know if a circle is a circle if we do not look down on it from space? In the social studies class, students can examine societies with rigid class structures and social systems that encourage prejudice and bigotry. In language arts, students can investigate satire and literature dealing with discrimination and prejudice. The reading list at the end of the chapter is a collection of fiction and biographies that focuses on discrimination, prejudice, and satire.

A Look at Flatland

MATHEMATICAL CONNECTIONS

geometry, data collection and analysis, ratios and percents

INTELLIGENCES

verbal/linguistic, logical/mathematical, interpersonal, intrapersonal, visual/spatial, bodily/kinesthetic

OTHER CURRICULAR CONNECTIONS

Social Studies: Class structures and social systems, intolerance

Language Arts: Literature, creative writing

CONCEPTS

Students will do the following:

1. Design regular polygons and circles to collect data about their attributes
2. Learn the size of the interior angles of regular polygons to construct their shapes
3. Analyze the results of their data collection activities
4. Make connections between literature and mathematics

MATERIALS NEEDED

poster board; rulers; protractors; compasses; scissors; copies of blacklines from this section; copies of Abbott's *Flatland* for each student

PROCEDURES

Each student needs a copy of the book to read. Although it is very short, the style is difficult and may require extensive discussion. The class structure described by Abbott is reminiscent of the satire of *Gulliver's Travels*. The rigid class structure and social customs of Flatland are indicative of the bigotry and class distinctions of a very narrow-minded society. These prejudices can be discussed in the larger context of historical and social implications.

The mathematical experiments allow students to test the theories of Flatland. Is it possible to distinguish shapes from a two-dimensional perspective? Is it easier to feel the difference than see the difference? Is there a shadow that helps distinguish multisided shapes?

Working collaboratively in groups of four, students have the opportunity to test these theories.

ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: use any or all questions from the "Story Questions" blackline on p. 229.

Two-Dimensional Shapes

Names ______________________________

____

Date ______________________________

Class ______________________________

"I call our world *Flatland*, not because we call it so, but to make its nature clearer to you . . . who are privileged to live in Space. Imagine a vast sheet of paper on which straight Lines, Triangles, Squares, Pentagons, Hexagons, and other figures, instead of remaining fixed in their places, move freely about, on or in the surface, but without the power of rising above or sinking below it, much like shadows—only hard and with luminous edges . . .

"Place a penny on the middle of one of your tables in Space and leaning over it, look down upon it. It will appear a circle. But now, drawing back to the edge of the table, gradually lower your eye (thus bringing yourself more and more into the condition of the inhabitants of Flatland), and you will find the penny becoming more and more oval to your view; and at last when you have placed your eye exactly on the edge of the table (so you are, as it were, actually a Flatlander) the penny will then have ceased to appear oval at all, and will have, so far as you can see, a straight line." (*Flatland*, 1–2)

Directions:

1. Work in your group of four and cut out the following shapes using posterboard:
   a. square
   b. isosceles triangle with a base (only) of three units
   c. pentagon
   d. octagon
   e. circle
2. Each of the sides should be 3 inches long. (Although the circle does not have sides, it should have the same ratio of length of sides as the polygon.) You will need some posterboard, a ruler, a protractor, compass, pencils, and scissors to accomplish this task.
3. Use these shapes to collect your data. Be sure that you cannot see the polygon from the perspective of three dimensions. You must be eye-level with the shape.

(Continued on next page)

Two-Dimensional Shapes (Continued)

4. Look at each shape from a two-dimensional perspective. Try to recognize the shape. Record on the table whether you were correct in recognizing the shape.

Circle whether or not the person's choice was correct.

Shape	**Person 1**	**Person 2**	**Person 3**	**Person 4**	**% Correct**
Square	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
Isosceles Triangle	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
Pentagon	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
Octagon	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
Circle	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
AVERAGE					

Recognizing Shapes

Names ____________________

____

Date ____________________

Class ____________________

> "Feeling is, among our Women and lower classes . . . the principal test of recognition. . . . Long practice and training, begun in the schools and continued in the experience of daily life enable us to discriminate at once, by the sense of touch, between the angles of an equal-sided Triangle, Square, and Pentagon; and I need not say that the brainless vertex of an acute-angled Isosceles is obvious to the dullest touch. It is therefore not necessary, as a rule, to do more than feel a single angle of an individual . . . unless he belongs to the higher sections of the nobility." (*Flatland*, 19–20)

Directions: Now use the shapes to see if you can feel the difference in shape by recognizing the difference in the size of the angles. Be sure that you close your eyes and randomly choose the shapes.

Circle the Correct Choice

Shape	**Person 1**	**Person 2**	**Person 3**	**Person 4**	**% Correct**
Square	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
Isosceles Triangle	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
Pentagon	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
Octagon	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
Circle	Correct Incorrect	Correct Incorrect	Correct Incorrect	Correct Incorrect	
AVERAGE					

Were you able to recognize one of the shapes better than others? ____________________

If yes, why do you think this occurred? ____________________

____

Explain what your group did to assure that you would not be able to see the shape three-dimensionally. ____________________

Which method (diagonal length or angle size) do you think was easier to determine? Why? ____________________

____

Attributes of Shapes

Names ______________________________________

____

Date ______________________________________

Class ______________________________________

> "Recognition by Feeling . . . is universal among the lower classes. It is only among the higher climates and in our more temperate climates that Sight Recognition is practiced. This . . . is the result of Fog; which prevails during the greater part of the year in all parts save the torrid zones.
>
> "If Fog were non-existent, all lines would appear equally and indistinguishably clear. But wherever there is a rich supply of Fog, objects that are at a distance, say of three feet, are appreciably dimmer than those at a distance of two feet eleven inches; and the result is that by careful and constant experimental observation of comparative dimness and clearness, we are enabled to infer with great exactness the configuration of the object observed." (*Flatland*, 25)

It is explained in *Flatland* that objects are recognized by sight because the sides recede into the fog and appear dim. Did the lengths of the diagonals or the number of degrees in the interior angles help us identify the shapes? Let's put our data on this table to help us answer that question.

Use the information on the table to answer whether the lengths of the diagonals or the number of degrees in the interior angles helped you identify the shapes.

Shape	% Correct	Length of Diagonal	Number of ° in the Interior Angle	Did we receive help because of the attributes of the shape?
Square				Yes No
Isosceles Triangle				Yes No
Pentagon				Yes No
Octagon				Yes No
Circle				Yes No

Story Questions

Names ______________________________

____

Date ______________________________

Class ______________________________

Flatland is a story about geometric shapes, but it is more than a mathematics lesson. It is a story that attributes human beliefs and attitudes to polygons. Use what you read in the story to answer these questions.

1. How do people in Flatland recognize each other? ______________________________

____

2. Are all of the inhabitants of Flatland equal or are some better than others? Explain your answer. ______________________________

____

Do we live in a society where people are equal? Explain your answer. ______________________________

____

____

3. What kinds of things are possible in a three-dimensional world that are not possible in a two-dimensional world? Explain your answer. ______________________________

____

4. Originally, the residents of Flatland enjoyed using color. Why did they have a problem and then forbid its use? ______________________________

____

Does this relate to problems you are familiar with? ______________________________

____

5. Discuss your feelings and thoughts of *Flatland*. Did you enjoy the book? Why or why not?

____

____

____

Grading Matrix

Names ________________________

____

Date ________________________

Class ________________________

Criteria	4	3	2	1
Accuracy of computation				
Quality of written responses				
Overall quality of project				

Comments:

Additional Reading

Beatty, P. 1981. *Lupita Manana.* New York: Morrow.

Lupita is thirteen years old when she and her family leave Mexico to enter California as illegal aliens. In constant fear of "la migra," she works to help her poverty-stricken family.

Celsi, T. 1991. *Rosa Parks and the Montgomery bus boycott.* New York: Millbrook Press.

A biography of the remarkable black woman who refused to give up her seat to a white man. Her defiance started the Montgomery bus boycott that helped bring down segregation in the South.

Flanigan, S. 1988. *Alice.* New York: St. Martin's Press.

Prejudice and discrimination are not unique to race relations—people with handicaps face these difficulties as well. Alice is deaf and is kept locked in a shed by her disturbed parents. Ellie and her brother try to help Alice.

Greenfeld, H. 1993. *The hidden children.* New York: Ticknor & Fields.

This book contains the personal narratives of Jewish children who were forced to go into hiding during the Holocaust and survived to tell the world of their ordeals.

Meyer, C. 1993. *White lilacs.* San Diego: Harcourt Brace Jovanovich.

In 1921, twelve-year-old Rose Lee is living in Dillon, Texas, when she sees trouble threatening her black community. This book describes the decline in race relations when the white residents of Dillon decide to take Rose Lee's land. They want to build a park and forcibly relocate the black families to an ugly stretch of land outside of town.

O'Dell, S. 1989. *My name is not Angelica.* Boston: Houghton Mifflin.

This historical novel tells the story of a young Senegalese girl who is brought as a slave to the Danish-owned Caribbean island of St. John. She later participates in the slave revolt of 1733–34.

Orwell, G. 1954. *Animal farm.* New York: Harcourt Brace.

A satire on totalitarianism in which farm animals overthrow their human owner and set up their own government.

Sebestyen, O. 1979. *Words by heart.* Boston: Little, Brown.

In a southwestern town in 1910, a young black girl struggles to fulfill her father's dream of a better future for their family. This book looks at some of the problems faced by a black family in an all-white town.

Spinelli, F. 1990. *Maniac Magee.* Boston: Little, Brown.

A homeless boy living in a large city finds himself caught between two sides of racial prejudice.

Taylor, M. 1991. *Roll of thunder, hear my cry.* New York: Puffin.

A black family living in the South during the 1930s is faced with prejudice and discrimination that their children do not understand.

Temple, F. 1993. *Grab hands and run.* New York: Orchard Books.

When his father disappears, twelve-year-old Felipe, his mother, and his sister set out on a long and dangerous journey—from their home in El Salvador to safety in Canada.

Wartski, M. C. 1980. *A boat to nowhere.* Philadelphia: Westminster.

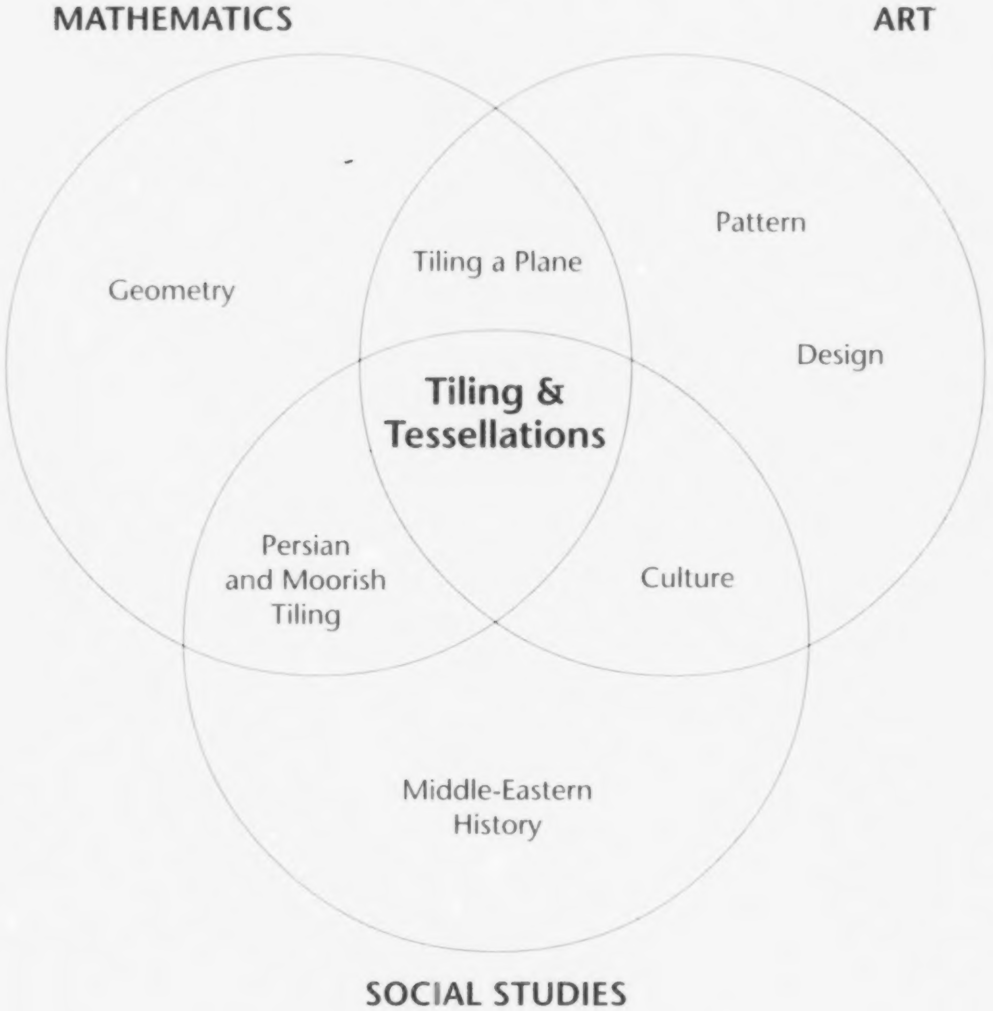
An old man and three children begin a seemingly hopeless journey. Fleeing from the communist government in Vietnam, they struggle to survive as boat people.

Zar, R. 1983. *In the mouth of the wolf.* Philadelphia: The Jewish Publication Society.

The author describes how she survived the Holocaust by following her grandfather's advice, to hide in the mouth of the wolf. By passing herself off as an Aryan and living in the house of the commandant, she was too close to be found.

CHAPTER 11

Tiling and Tessellations


MATHEMATICS
ART
Geometry
Tiling a Plane
Pattern
Design
Tiling & Tessellations
Persian and Moorish Tiling
Culture
Middle-Eastern History
SOCIAL STUDIES

CHAPTER 11

Tiling and Tessellations

A good part of art is based upon geometry.

—Giraud Desargues

Geometric tilings (tessellations) are an important aspect of both mathematics and art. In addition, because intricate geometric patterns are the basis of Middle Eastern art, these harmonious designs help connect this activity to social studies and Asian culture.

Around 4000 B.C., the Sumerians in the Mesopotamian Valley decorated their homes and temples with geometric tiles. Persian and Moorish architecture abounds with magnificent tiling patterns on the floors and walls of its buildings. The Romans called the tiles they used to decorate their buildings "tellellae." This Roman word forms the root for the modern term tessellation.

Arabic, or Islamic, art has become synonymous with decorative tiling. Islamic art is considered a sacred geometry. "At the basis of this geometry there lies the circle which is an image of an infinite whole and which, when it is evenly divided, gives rise to regularly shaped polygons which can . . . be developed into star-shaped polygons elaborated indefinitely in perfectly harmonious proportions" (El-Said 1976, ix).

The creative mathematics lesson in this chapter brings together geometric concepts and the designs found in the tessellating or tiling of regular polygons. A regular polygon is a geometric shape in which all sides and all angles are congruent. The tessellations in this activity employ regular polygons.

Students begin by attempting to tile the plane, using more than one regular polygon. To complete this project, students learn how to calculate the interior angles of a polygon.

Semiregular Tessellations

MATHEMATICAL CONNECTIONS

regular polygons, angle measurement, symmetry

INTELLIGENCES

logical/mathematical, visual/spatial, intrapersonal

OTHER CURRICULAR CONNECTIONS

Art: Decorative tiling and architecture

Social Studies: Middle Eastern culture and history

CONCEPTS

Students will do the following:

1. Experiment in an attempt to find two or more regular polygons to tile the plane
2. Learn how to calculate the size in degrees of the interior angles of regular polygons
3. Use interior angles to find all eight semiregular tessellations
4. Tile and decorate a plane

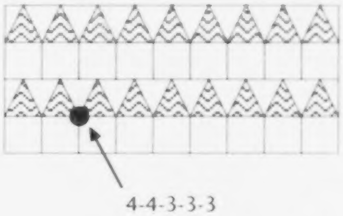
MATERIALS NEEDED

a copy of "Regular Polygons" for each student; tagboard or old file folders; glue sticks or rubber cement; scissors; paper; markers or colored pencils; overhead transparency of blacklines (for the teacher); copies of blacklines (for students)

PROCEDURES

Give students the sheet of regular polygons. Discuss the names of the polygons and that their measurements are unique because each of their sides has the same measurement. They are congruent. When each student has the necessary supplies, tell them they are to glue the polygon sheet onto the tagboard and carefully cut out each shape. Accuracy is of the utmost importance since these shapes will serve as "puzzle pieces" for finding semiregular tessellations.

Semiregular tessellations are tilings where each and every vertex point is congruent. That is, the same polygons appear in the same order at each vertex point. Here is an example of a 4-4-3-3-3 semiregular tessellation:



This is called a 4-4-3-3-3 tessellation because at each vertex we find:

square (4), square (4), triangle (3), triangle (3), triangle (3)

After students have found two or three of the possible eight semiregular tessellations, give them a copy of the blackline "To Tessellate or Not to Tessellate." Explain that there might be a mathematical way of figuring out why some combinations of polygons work and some do not. (Note: This is a "real-world" application of interior angles of regular polygons.)

Work at the overhead projector with the transparency while students complete the paper at their seats. Once students understand that the sum of the angles at each vertex point is 360°, they are ready to find all of the semiregular tessellations.

This is a table of all of the semiregular tessellations:

	Numerical Code	Geometric Shapes
1	3-3-3-3-6	Four triangles and a hexagon at each vertex
2	4-6-12	A square, a hexagon, and a dodecagon at each vertex
3	3-12-12	A triangle and two dodecagons at each vertex
4	4-4-3-3-3	Two squares and three triangles at each vertex
5	3-4-6-4	A triangle, a square, a hexagon, and another square at each vertex
6	6-3-6-3	A hexagon, a triangle, a hexagon, and a triangle at each vertex
7	3-3-4-3-4	Two triangles, a square, a triangle, and a square at each vertex. Note: this differs from #4 because of the order or arrangement of polygons.
8	4-8-8	A square, and two octagons at each vertex. Note: this is the only semiregular tessellation that uses octagons.

ASSESSMENT

1. Student products—Successful completion of semiregular tessellation and blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "Explain why pentagons and decagons will not tessellate the plane."

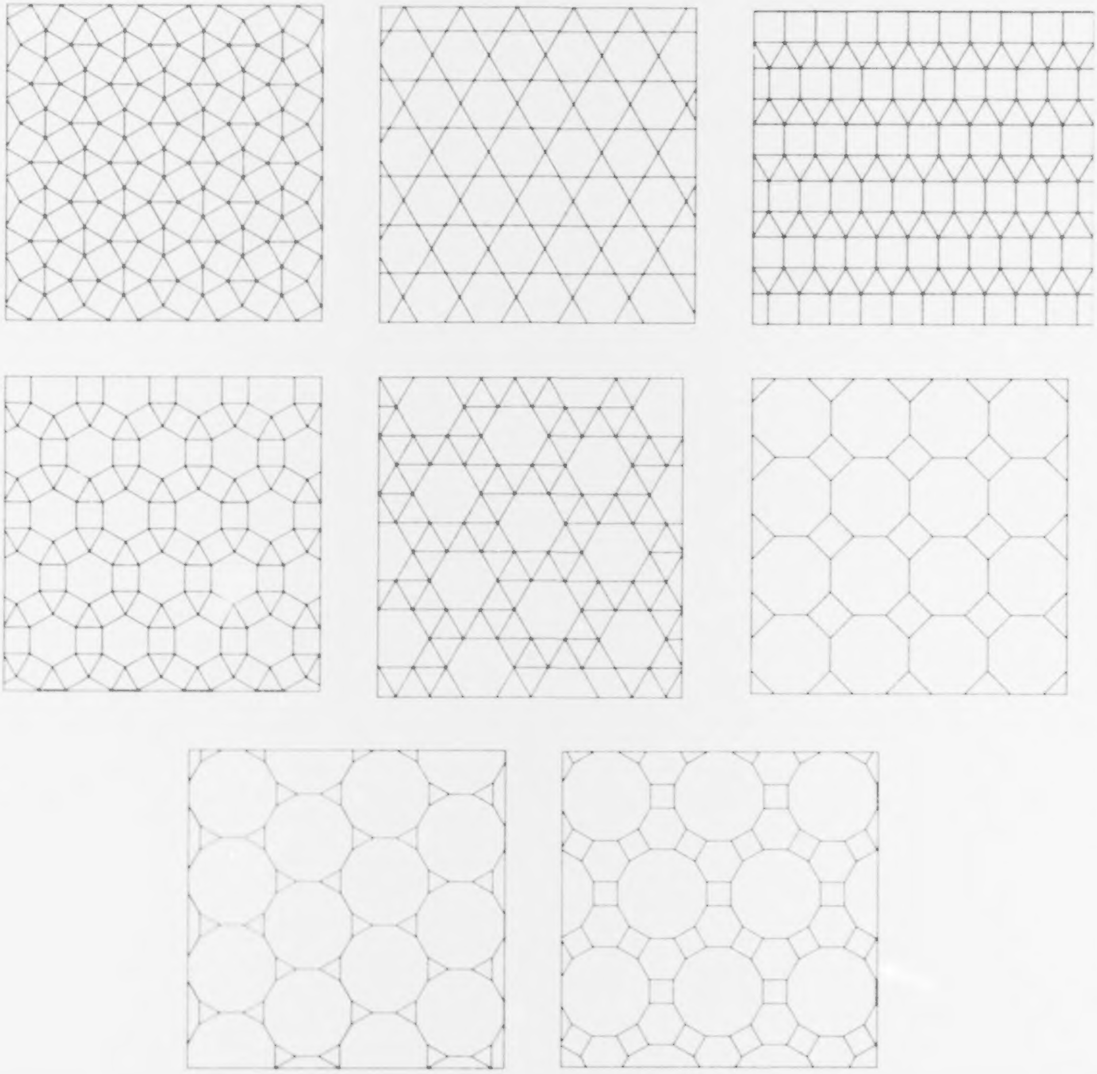
Semiregular Tessellations

Names ______________________________

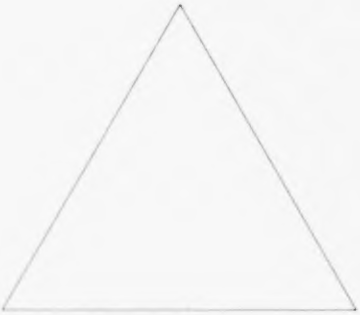
____

Date ______________________________

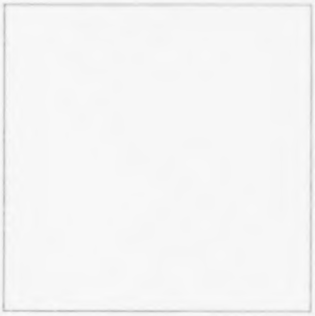
Class ______________________________



Regular Polygons

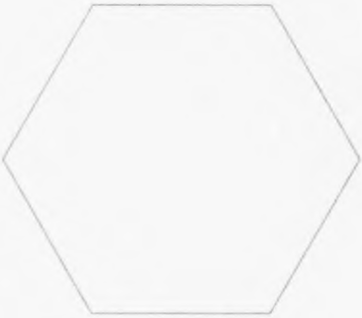


Equilateral Triangle

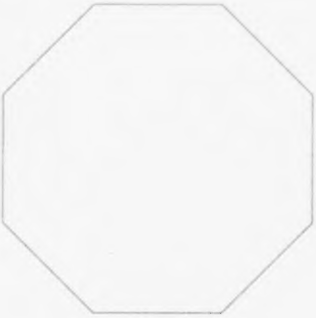


Square

Pentagon



Hexagon



Octagon

Decagon

Dodecagon

To Tessellate or Not to Tessellate?

Names ______________________________

____

Date ______________________________

Class ______________________________

Directions: We know that a triangle contains 180°; let's use this knowledge to complete the table below. Maybe it will help us figure out why some of the combinations of regular polygons tesselated and other combinations did not. Use your calculators (if you wish) to do the computation required. What is the sum of the angles at each vertex of semiregular tessellations?

Polygon	Number of Triangles	Number of Triangles x 180°	Total # of Degrees	Number of Degrees in Each Interior Angle	Total # of Angles
Triangle					
Square					
Pentagon					
Hexagon					
Octagon					
Decagon					
Dodecagon					
An "N" sided Polygon					

Grading Matrix

Names ______________________

____

Date ______________________

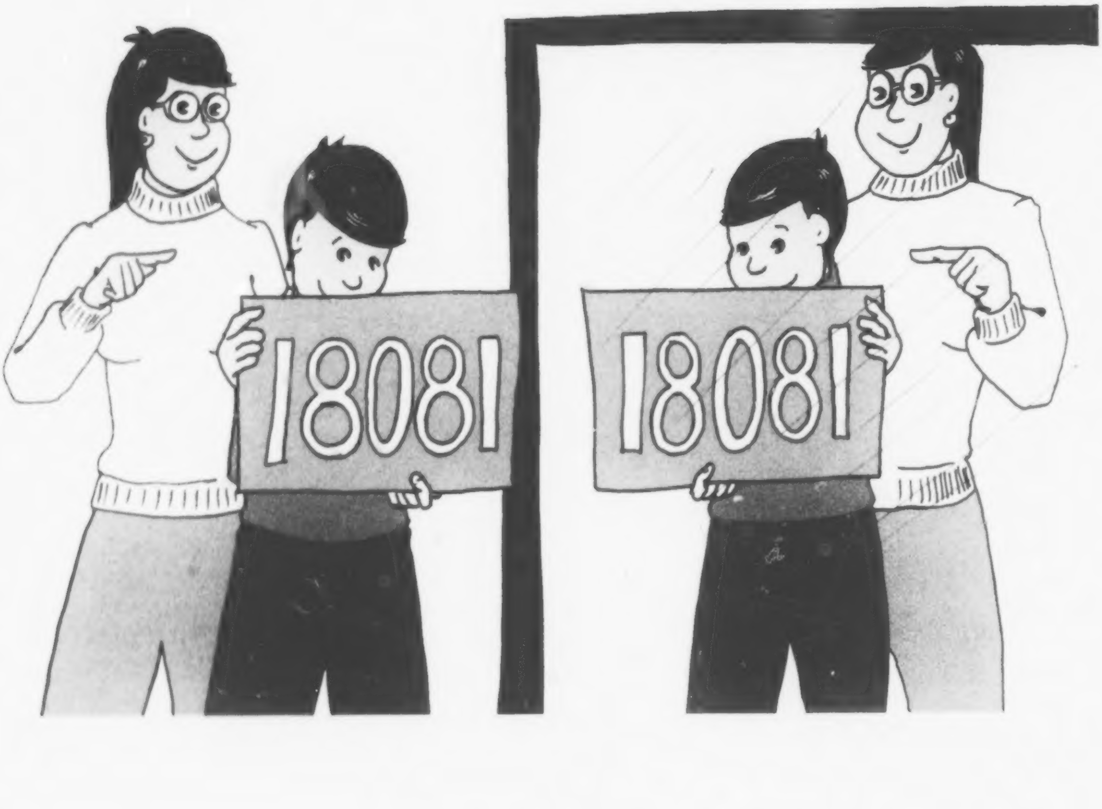
Class ______________________

Criteria	**4**	**3**	**2**	**1**
Accuracy of computation				
Quality of written responses				
Overall quality of project				

Comments:

CHAPTER 12

Designs in Regular Polyhedra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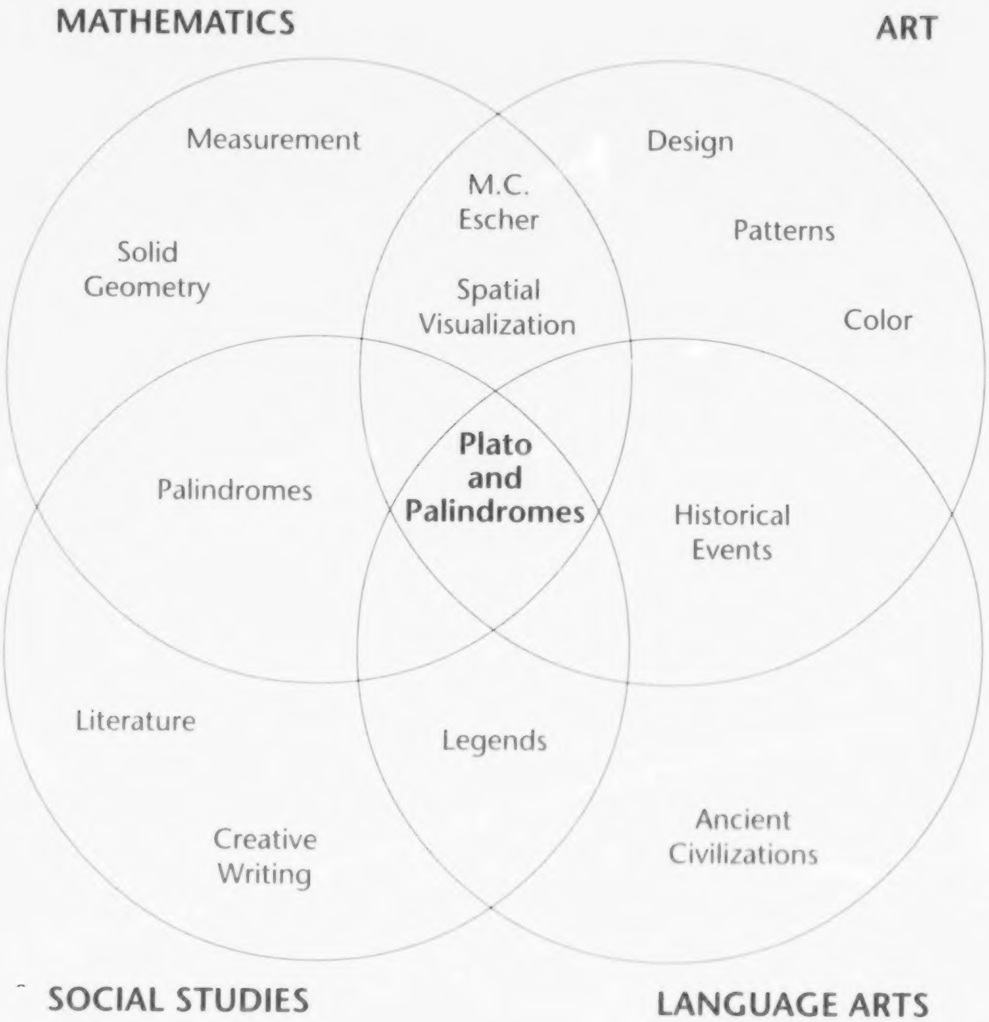
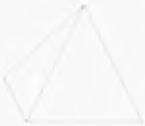

MATHEMATICS
ART
Measurement
Design
M.C. Escher
Patterns
Solid Geometry
Spatial Visualization
Color
Plato and Palindromes
Palindromes
Historical Events
Literature
Legends
Ancient Civilizations
Creative Writing
SOCIAL STUDIES
LANGUAGE ARTS

CHAPTER 12

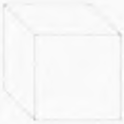
Designs in Regular Polyhedra

This interdisciplinary unit makes connections between the solid geometry (dating back to about 350 B.C.) of the Greek philosopher Plato and palindromic sequences and artistic design.

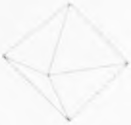
Plato studied regular polyhedra, which are geometric solids whose faces are all congruent. These polyhedra also have the same number of faces meeting at each vertex. There are only five regular convex polyhedra:



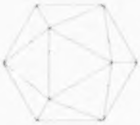
Tetrahedron



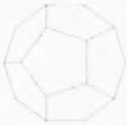
Hexahedron (Cube)



Octahedron



Icosahedron



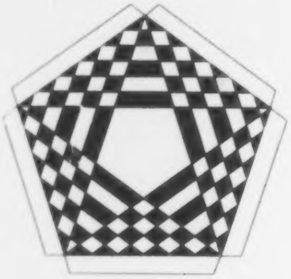
Dodecahedron

Because of Plato's interest in these regular polyhedra, they are called Platonic solids. The ancient Greeks believed the five solids corresponded to the following elements of the universe:

Tetrahedron	Fire
Hexahedron	Earth
Octahedron	Air
Icosahedron	Water
Dodecahedron	Universe

This lesson uses one of Plato's solids, the dodecahedron, as the foundation for a project rich in interdisciplinary perspectives. Let's examine the multicurricular connections incorporated in this lesson.

Students learn about art by designing a dodecahedron and finding out about the Dutch artist M. C. Escher. To design the dodecahedron, the students develop a number sequence that has a vertical line of symmetry (in other words, it's a palindrome). After measuring their pattern off on each side of twelve pentagons, they complete a design similar to the one shown here:

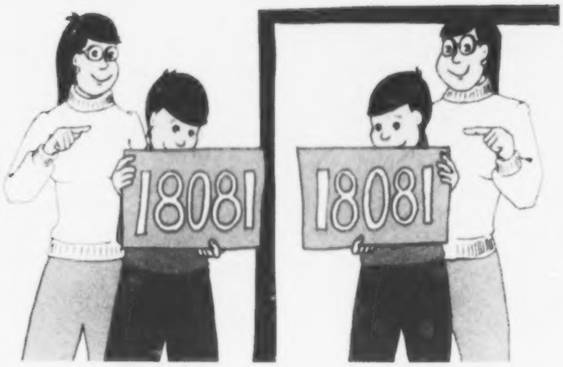


Escher was fascinated by the Platonic solids and they played a significant role in his art. In discussing his use of these polyhedra, Escher said, "They symbolize man's longing for harmony and order, but at the same time, their perfection awes us with a sense of our own helplessness. Regular polyhedra are not the inventions of the human mind, for they existed long before mankind appeared on the scene" (Lochner 1971, 49). In the book *Escher on Escher,* the artist discusses some of his prints. He says about Order and Chaos: "The perfectly ordered beauty of a stellated dodecahedron, combined with a translucent sphere, like a soap bubble, is surrounded by a collection of useless, cast-off, and crumbled objects. I had to make a very careful choice among the many heterogeneous objects of a rubbish dump, for every piece had to be recognizable" (p.70). A large collection of Platonic solid prints can be found in *M. C. Escher—29 Prints.*

In social studies, students can examine the great civilization of the ancient Greeks and their effect on our modern world. Ancient worlds are an integral part of the middle school social studies curriculum and this project is a thoughtful extension of the Egyptian and Sumerian worlds.

In language arts class, students can examine palindromes and use their creative writing skills to generate their own. Palindromes have played a fascinating role in language as well as mathematics. They can be words, numbers, or even musical notes. Words such as "racecar," "reviver," and "rotator" can be written the same backward and forward. A famous palindrome is the epitaph of Ferdinand de Lesseps, "A man, a plan, a canal, Panama!" who was associated with the famous canal. We even have whole sentences, such as an amazing one written in 1967 by James Michie, "Doc note, I dissent. A fast never prevents a fatness. I diet on cod." There are even tongue-twisters, such as Leigh Mercer's: "Top step's pup's pet spot."

A mathematical palindrome is a number sequence that has a line of symmetry in the center. For example, 1991 is a palindrome whose line of symmetry is between the two nines; 2991992 is a palindrome whose line of symmetry is the one. In mathematics class, the students can develop number palindromes, and in language arts class, students can design more conventional ones.



Plato and Palindromes

MATHEMATICAL CONNECTIONS

measurement, solid geometry

INTELLIGENCES

logical/mathematical, visual/spatial, intrapersonal

OTHER CURRICULAR CONNECTIONS

Art: Design, spatial visualization, M. C. Escher's art

Social Studies: Ancient cultures

Language Arts: Palindromes, creative writing

CONCEPTS

Students will do the following:

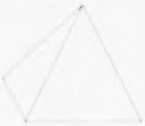
1. Use a pentagon template to cut twelve templates
2. Design a palindromic number that has a sum of 6.5 centimeters
3. Create a design using their number sequence
4. Assemble a dodecahedron using their pentagons

MATERIALS NEEDED

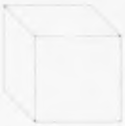
template of pentagon; scissors; metric ruler; colored pencils; glue sticks or rubber cement

PROCEDURES

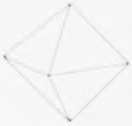
Platonic solids are polyhedra whose sides are congruent polygons. There are only five of these regular polyhedra, which are shown below:



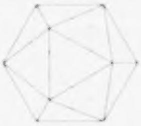
Tetrahedron



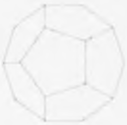
Hexahedron
(Cube)



Octahedron



Icosahedron



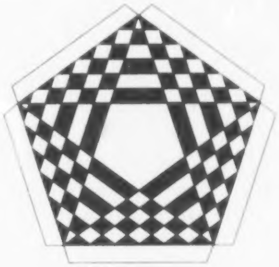
Dodecahedron

Discuss these with students and explain how each was believed to be elements of the Universe:

Tetrahedron	Fire
Hexahedron	Earth
Octahedron	Air
Icosahedron	Water
Dodecahedron	Universe

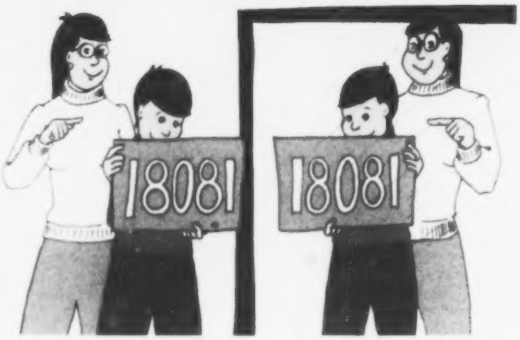
The pentagon web on the "Make a Dodecahedron" blackline is 6.5 centimeters on each side. Students need to design a palindromic number sequence whose sum is equal to 6.5. The design shown on the blackline can be formed by measuring the sequence on each side of each of twelve pentagons and connecting the adjacent sides.

Accuracy in measurement is required if the design is to be successful. Encourage students to use colored pencils to create an attractive design. A sample is shown here:



ASSESSMENT

1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "Discuss the Platonic solids. Be sure to explain how many there are, how their names refer to the number of faces, and the polygons that constitute each."



Platonic Solids

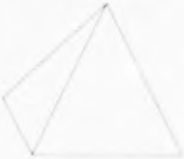
Names ______________________________

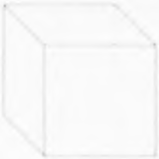
____

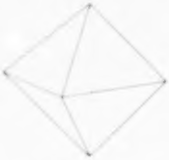
Date ______________________________

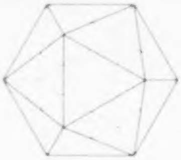
Class ______________________________

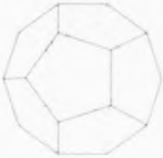
In 350 B.C., Plato, a Greek philosopher, showed how to construct five special polyhedra, which are three-dimensional, solid geometric shapes. He wrote about them in his book *Timaeus*, and the solids became known as the Platonic solids. These are regular polyhedra because each of the faces is a congruent polygon and the same number of faces meet at each vertex. The five polyhedra below are the Platonic solids. Be sure to examine each of the faces and vertices:


Tetrahedron


Hexahedron
(Cube)


Octahedron


Icosahedron


Dodecahedron

The ancient Greeks believed that each of these solids harmonized to elements in the Universe. They are the following:

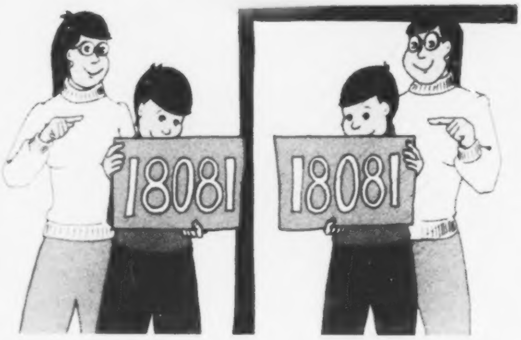
Tetrahedron = Fire
Hexahedron = Earth
Octahedron = Air

Icosahedron = Water
Dodecahedron = Universe

Use the polyhedra above to answer the following.

What polygons make up these solids:

1. Tetrahedron ______________________________
2. Hexahedron ______________________________
3. Octahedron ______________________________
4. Icosahedron ______________________________
5. Dodecahedron ______________________________



Make a Dodecahedron

Names ______________________________

____

Date ______________________________

Class ______________________________

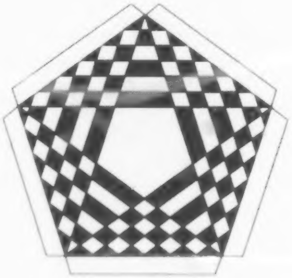
Use the pentagon below as a pattern and cut out an additional eleven pentagons to make a dodecahedron (there are three pentagons at each vertex of a dodecahedron). Measure one side of the pentagon. It should be 6.5 cm long. This is an important measurement. It will be used to design your dodecahedron.

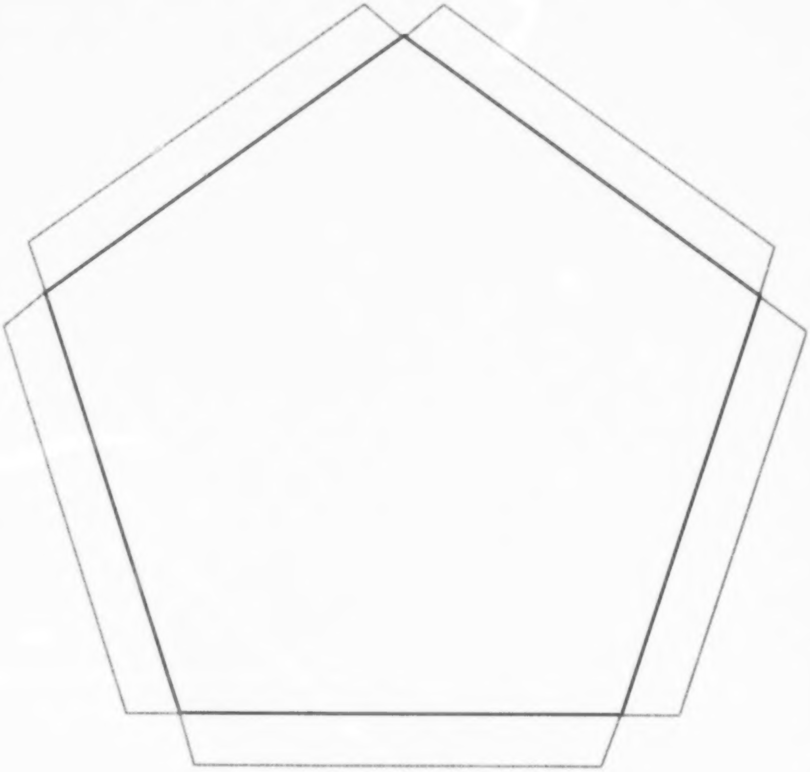
Find a numerical palindrome (it looks the same whether you read it from right to left or left to right). The center of the number should be an invisible line of symmetry. For example:

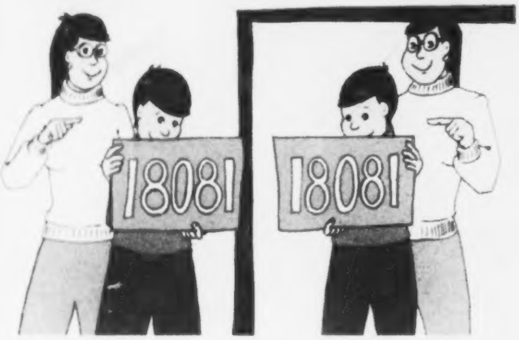
.5 1 .5 1 : 1 .5 1 .5

.5 1 .5 1 .5 1 .5

Your palindromic sequence must have a sum of 6.5 because that is the length of each side of the pentagon. Measure your sequence on each side and connect the measurements side to side to form a design. It will look something like this when it is completed:







Grading Matrix

Names ____________________

____

Date ____________________

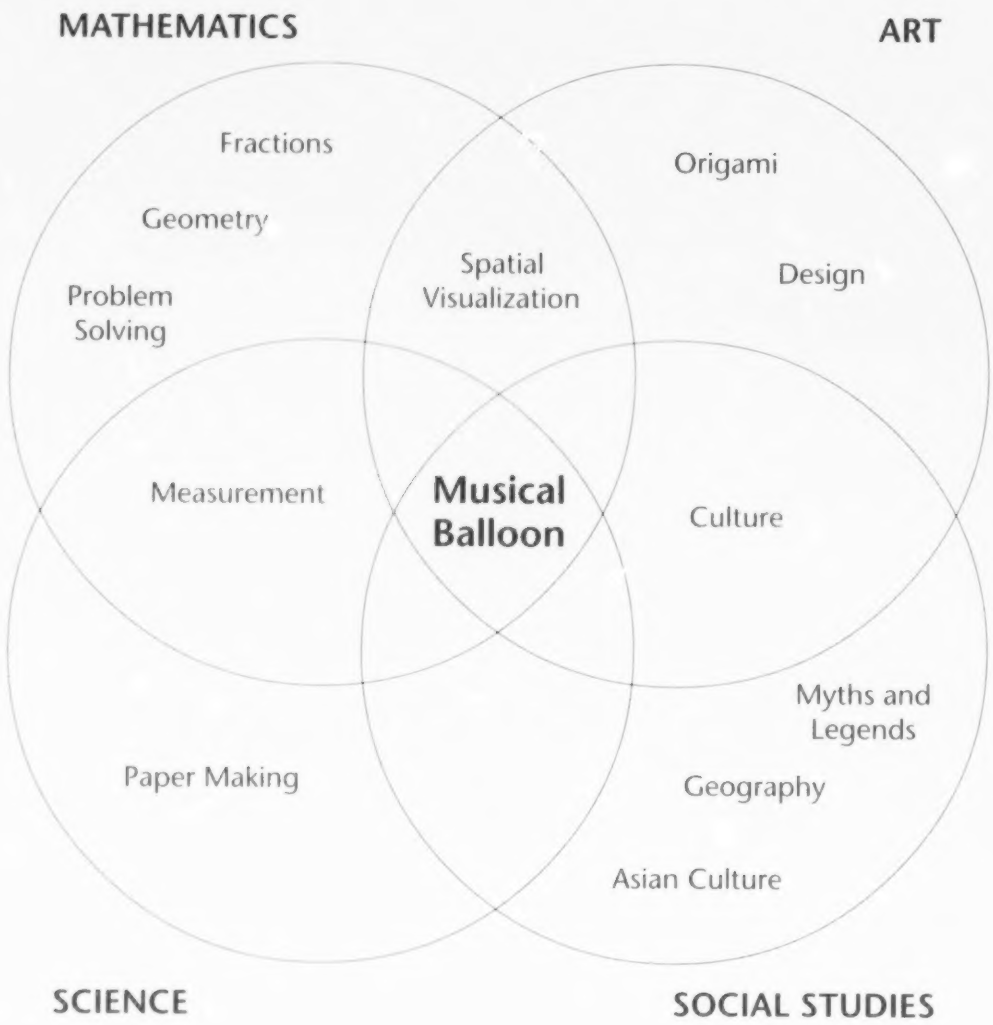
Class ____________________

Criteria	4	3	2	1
Accuracy of computation				
Quality of written responses				
Overall quality of project				

Comments:

CHAPTER 13

Origami, Music, and Math


MATHEMATICS
ART
Fractions
Geometry
Problem Solving
Origami
Spatial Visualization
Design
Measurement
Musical Balloon
Culture
Myths and Legends
Paper Making
Geography
Asian Culture
SCIENCE
SOCIAL STUDIES

CHAPTER 13

Origami, Music, and Math

This lesson makes unique connections between Asian history, artistic paper folding, and informal geometry. Origami, the art of Japanese paper folding, is the basis for the lesson. In Japan, students learn origami in kindergarten and it is part of the nation's ancient cultural heritage. We can take advantage of the built-in motivation and interest of students to explore geometric shapes and fractional parts while encouraging them to develop their visual/spatial intelligence.

It is believed that origami was brought to Japan from China by a Buddhist monk shortly after the invention of paper. Many of the original folds were very formal and ritualistic. However, through time, the art of origami has been made more accessible to everyone, and now it takes the form of birds, fish, insects, animals, and even geometric shapes. Origami is a handicraft enjoyed worldwide. It is very popular as a hobby in the United States as well as in Spain and Latin America.

In the social studies classroom, the art of origami can be studied from the viewpoint of the culture and tradition of the Eastern cultures. Also, because of its ties to Japan, origami can be tied to the history of World War II and Hiroshima.

In mathematics classes, paper folding has been used to visually explore geometric constructions. Students begin by using traditional origami folds to build a paper balloon that, when opened, produces an extraordinary assortment of geometric shapes. In order to take advantage of the diversity of this design, the first activity asks students to identify all of the geometric shapes they can find and explain the relationships they see.

After the musical balloon is folded, dried beans can be placed inside and an "ethnic" percussion instrument is formed. Students should be encouraged to read the music written for percussion and play a tune with their musical balloons.

The Musical Balloon

MATHEMATICAL CONNECTIONS

spatial visualization, geometry, fractions, area

INTELLIGENCES

visual/spatial, logical/mathematical, musical/rhythmic, interpersonal, verbal/linguistic

OTHER CURRICULAR CONNECTIONS

Science: Chemistry (making paper)

Social Studies: History, Asian culture

Art: Design, origami

Music: Percussion rhythms

CONCEPTS

Students will do the following:

1. Follow oral directions to fold an origami balloon
2. Use the folds to increase their knowledge of geometric shapes
3. Use the origami balloons as percussion instruments

4. Make connections between musical timing and fractions

MATERIALS NEEDED

a six-inch square of origami paper for each student; copies of blacklines from this section for each student; markers, crayons, or colored pencils

PROCEDURES

After giving students a copy of the directions, go through each step with them. Instruct the students what to do as you demonstrate the fold. If the students are working in pairs, they can help each other with difficult folds. Take advantage of students for whom origami is a hobby—they can be a big help with students who are having difficulty.

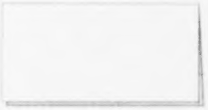
The "Polygon Identification" blackline is a copy of the balloon after it has been folded and reopened. Students can describe all of the polygons and answer questions in their journals. They should be encouraged to color in the design to enhance its symmetry.

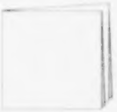
When the origami balloons are completed, there is a little hole at one end. Small beans can be dried and placed in the balloons to make percussion instruments. The music on the "Making Music with a Musical Balloon" blackline is written using $^{1}/_{16}$ notes.

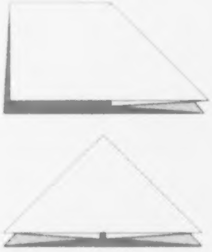
ASSESSMENT

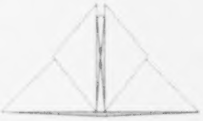
1. Student products—Successful completion of blacklines
2. Observation of students
3. Grading matrix
4. Journal question: "Use your journal to sketch and describe polygons."

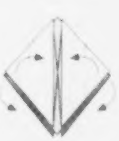
Directions for Folding a Musical Balloon

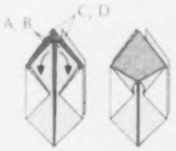
1.


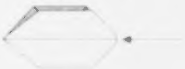
2.


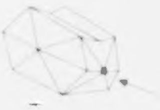
3.


4.


5.


6.


7.


8.


1. Begin with a 6" square piece of paper. Fold it in half. Fold it in half again, creating a square. The openings should be on the right and bottom.
2. Fold the right bottom corner of the front side of the square on the diagonal, as shown. Turn over and repeat on the back side. You should end up with a triangle.
3. Unfold the flaps and return the paper back to the small square, with the folds on the left and top sides. There are now four corners on the bottom right side. Hold the square by the bottom left corner. Using your other hand, grasp the inner two corners on the right, bottom side of the square. Pull these corners out to form a triangle at the top of the square. Now turn the paper so that the square of the paper is on the left. Push in the top part of the square to make the paper a triangle with peak-and-valley folding.
4. Fold the bottom corners up to the top of the triangle. Turn over and repeat.
5. Fold the right and left points into the center line. Turn over and repeat.
6. Fold the loose top corners (A and B) outward into the pockets. Turn over and do the same with points C and D.
7. Fold the left and right edges of the balloon shape together. Repeat on the other side. The pockets should now be hidden. Blow air into the indicated hole—this will inflate the balloon.
8. Carefully place dried beans in the opening. The musical balloon is finished.

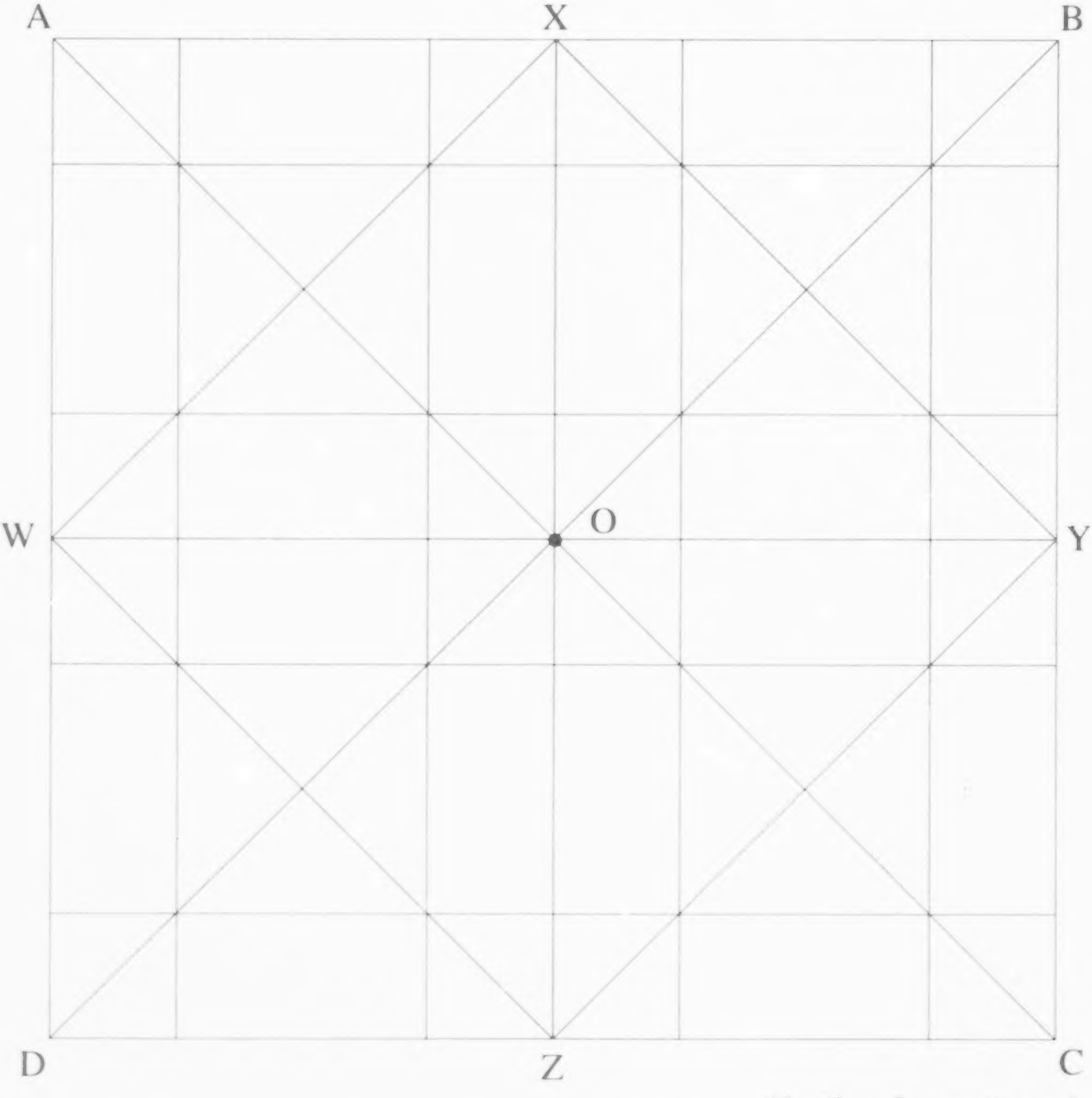
Polygon Identification Sheet

Name(s) ______________________________

____

Date ______________________________

Class ______________________________



(Continued on next page)

Polygon Identification Sheet (Continued)

What geometric shapes can you find in this representation of the musical balloon? Can you find a right triangle? A rectangle? A square? A trapezoid? A parallelogram? ______________________

____

____

____

What is the relationship between the area of square ABCD and square WXYZ? ______________

____

____

____

Square WXYZ comprises four smaller squares. What fractional part of square ABCD is one of these small squares? ______________________________

____

____

____

Find the smallest triangle. What fractional part of the whole square (ABCD) is this small triangle?

____

____

____

____

Use markers, colored pencils, or crayons to color in this design. Be sure to take advantage of the lines of symmetry in the design.

Making Music with a Musical Balloon

Name(s) ______________________

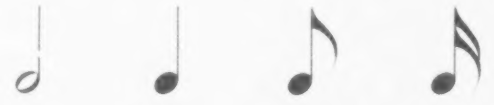
____

Date ______________________

Class ______________________

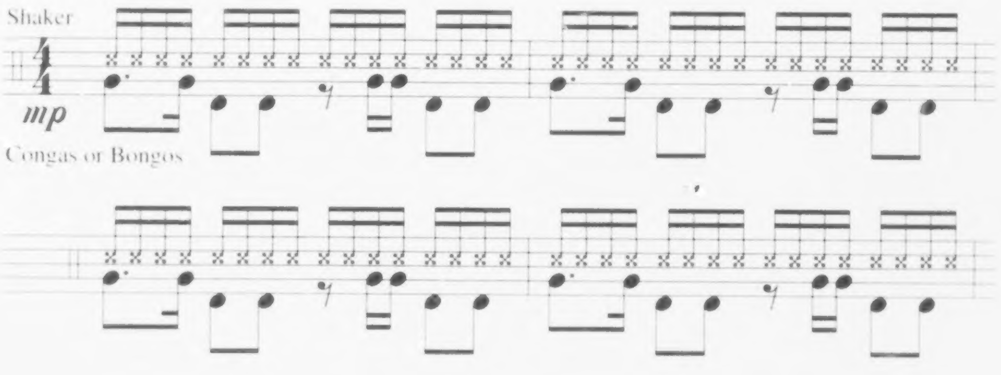
The notes below show what $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, and $\frac{1}{16}$ notes look like. If music is written in $\frac{4}{4}$ time, then a $\frac{1}{2}$ note is given two beats, and a $\frac{1}{4}$ note gets one beat.

How many beats will a $\frac{1}{8}$ note get? ______________ A $\frac{1}{16}$ note? ______________



$\frac{1}{2}$ note $\frac{1}{4}$ note $\frac{1}{8}$ note $\frac{1}{16}$ note

The music below was written for a percussion instrument called a shaker. It is written in $\frac{4}{4}$ time, but the notes are $\frac{1}{16}$ notes. Use the musical balloon to play the rhythms of this tune.



How many $\frac{1}{8}$ notes would you have in each of these measures? ______________

How many $\frac{1}{4}$ notes? ______________ How many $\frac{1}{2}$ notes? ______________

Grading Matrix

Name(s) ______________________________

____

Date ______________________________

Class ______________________________

Criteria	4	3	2	1
Accuracy of computation				
Quality of written responses				
Overall quality of project				

Comments:

Additional Reading

Coerr, E. 1977. *Sadako and the thousand paper cranes.* New York: Dell.

This is the true story of Sadako, a little girl who lived in Japan from 1943 until 1955. She died as a result of the bombing of Hiroshima.

Greene, C. 1983. *Japan.* Chicago: Children's Press.

An interesting reference book that describes some of Japan's features, including the geography, history, scenic beauty, culture, industries, and people.

Honda, I. 1965. *The world of origami.* Tokyo: Japan Trading Publications Co.

This book contains an extensive explanation of the folds and symbols used in origami and illustrates 131 different origami forms, including compound figures.

Lang, R. J. 1992. *Origami animals.* New York, N. Y.: Crescent Books.

An introduction to origami including a look at different papers, symbols, and terms. The animal kingdom is divided up by the animals' place of residence: the American Meadow, the Swiss Alps, the Louisiana Bayou, the Ocean, the Arctic Ice, the Australian Forest, or the African Savanna. Also, the folds are divided by level of difficulty.

Mori, K. 1993. *Shizuko's daughter.* New York: Holt.

Yuki's mother commits suicide when Yuki is twelve years old. She is sent far from her mother's family to live with her father and his not-too-pleased new wife. Her inner strength helps her cope with her tragedy.

Salisbury, G. 1994. *Under the blood-red sun.* New York: Delacorte Press.

Tomikazu lives in Hawaii and his biggest concerns are school, his love of baseball, and his fear of a local bully. When Pearl Harbor is attacked in 1941, his life changes dramatically.

Uchida, Y. 1991. *The invisible thread.* New York: Messner.

This autobiography describes what it was like to grow up in California as a Nisei (a second-generation Japanese American) during World War II. The author recounts her family's internment in a Nevada concentration camp.

Yep, L. 1995. *Hiroshima.* New York: Scholastic.

A novella that describes the dropping of the atomic bomb on Hiroshima and its effect on Sachi, who becomes one of the Hiroshima Maidens.

Appendix A

Design Your Own Lessons

GETTING STARTED

Knowledge is not isolated into discrete, neat subject areas. As research indicates, students will not learn unless they can make connections and construct knowledge from previously learned information. How do you get started? Meet with members of your team and consider the priorities of your individual curriculums; delineate concepts and skills that overlap and are interrelated. This can be done using a shared model of integration, which requires teamwork but not extensive planning or altering of schedules. Examples of this model are the roller coaster lessons in chapter 8. The science teacher works on the physics of motion and gravity while the mathematics teacher works on substitution for a variable, problem solving, and algebra.

Shared integration explorations can be expanded since most topics can support an extensive model of integration. What is necessary for more comprehensive integration?

CURRICULUM-WRITING TIME

By taking time to write a curriculum, teachers can explore the interrelationships between subjects and their shared skills and concepts. Teachers can do this during summer curriculum work or, if time is available during the school year, during released-time. While not all of the integrated learning experiences in this book require extensive planning, they do require teachers to meet, plan for integrated instruction, and collaborate on teaching strategies.

RESPECT FOR OTHERS' CURRICULUM PRIORITIES

When teachers believe that their curricula are being respected and seriously considered, they are likely to become interested and involved members of the planning team. Usually on middle school or high school teams there are "subject-area" specialists; these teachers have a great deal of knowledge about their own curriculum. This knowledge should be used in a positive way to develop strong and vital interdisciplinary experiences.

FLEXIBILITY OF TIME

When students go to a local river to examine its macroorganisms, they need to have enough time to complete their experiments. The teacher team needs to be able to modify its schedule or have block scheduling for greater flexibility of time. According to Robin Fogarty (1995), "Block scheduling that fosters the use of in-depth projects and project-oriented learning is a viable way to integrate curriculums" (p.15).

THE FIRST STEPS

Meet as a Team and Become Familiar with Others' Curricula

1. What are the major skills and concepts in your curriculum?

2. What do you currently do to achieve your educational goals?

Brainstorm a Wish List of Topics

Finish the following sentences:

1. I have always wanted to explore . . .

2. I would love to work with the __________ teacher to develop . . .

3. I feel my strengths in curriculum design are . . .

Explore Intercurricular Connections among Disciplines

1. Clearly define the exploration.
2. Use one of the Venn models to help delineate the connections.

DESIGNING THE PROGRAM

You are now ready to delineate the components of the activity. At this point, the expertise of each team member can be used in a positive way to create a new and exciting curriculum. As you work, keep in mind any scheduling problems that may arise and clearly define concepts and skills to help with continual assessment of learning. As a team, you have defined the connections on the Venn diagrams. Now, as the individual mathematics teacher, you can use the "teacher's page" to help define your own activities and their interconnections to the team project.

DEFINING ASSESSMENT

Authentic assessment of your project will require alternatives to paper-and-pencil tests. Consider student products, observation, interviews, and journal question(s) to help you assess student learning. A blank matrix has been supplied to assist you. When defining the criteria for the matrix, clearly consider the concepts and skills of the project. These will help define criteria.

Student Products

Are the blacklines correct? Was there creativity in problem solving? Analyze the products of the lesson. These will show what was actually accomplished.

Observation of Students

Many of the lessons and projects require the active involvement of students. Observe how well the students work in their groups and what each student contributes to the final product. This type of observation provides a clear indication of the students' understanding.

Interviews

As you walk around observing students, stop and question them: Can you explain to me what you're doing? Why do you think that happened? Did anyone in the group have another idea of how this might be done?

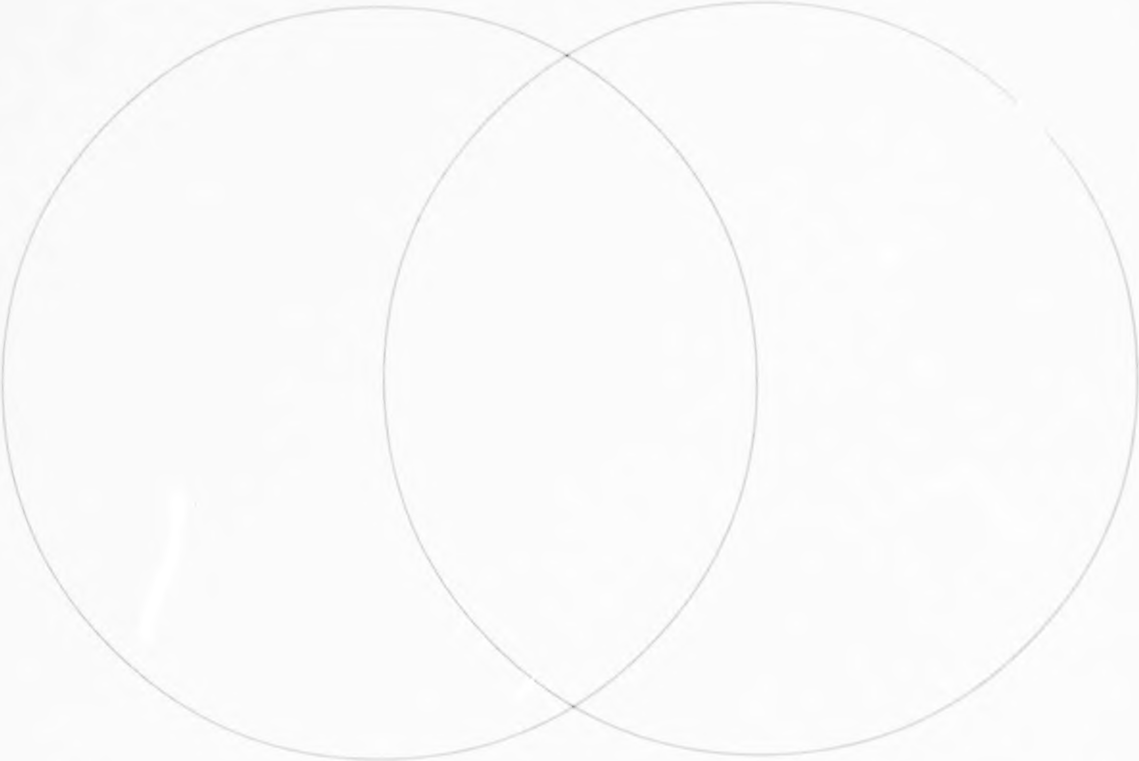
Journal Questions

Having students explain their solutions in verbal form encourages the development of the verbal/linguistic intelligence and permits assessment of concepts, as opposed to lower-level thinking skills.

Blank forms are provided to assist your team with their planning from the birth of the idea to the assessment of student learning.

Two-Subject Venn

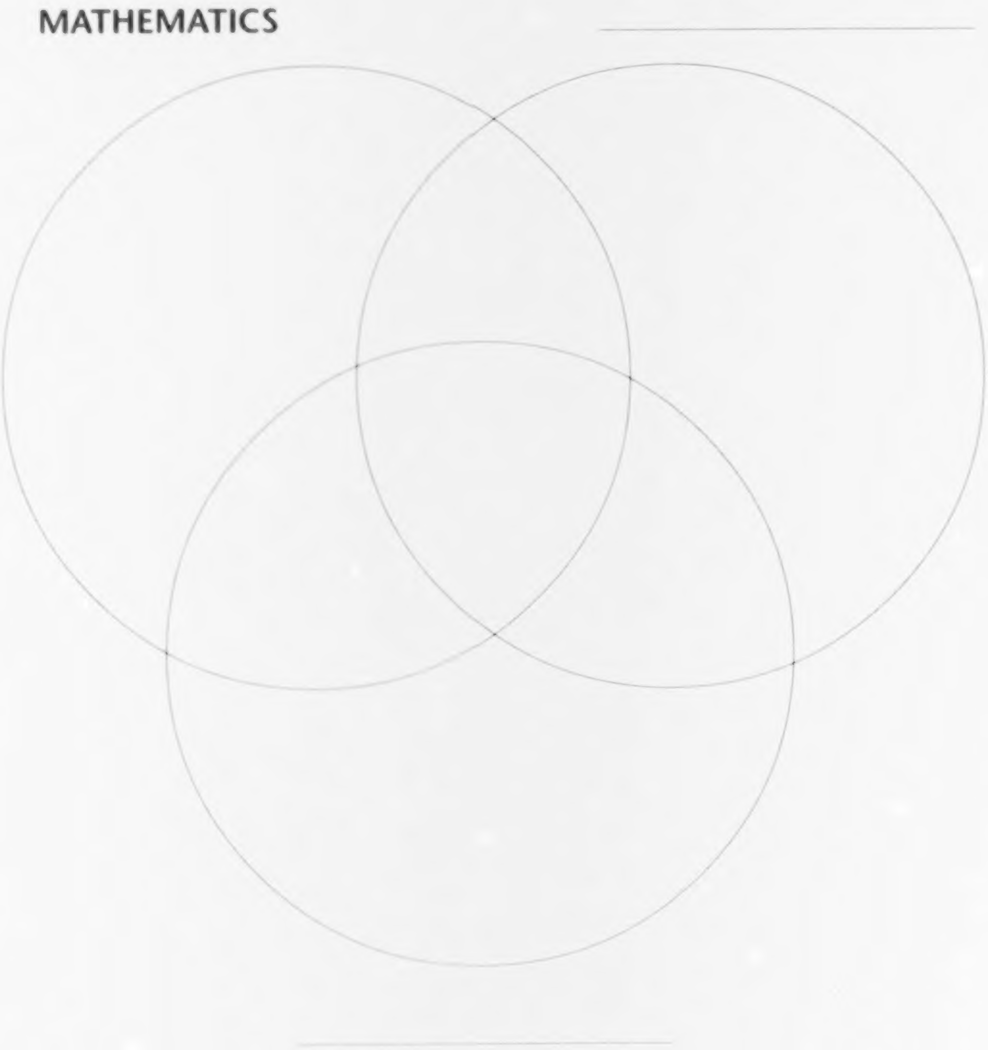
MATHEMATICS ____________________



TOPIC: ____________________________________

Use the two-subject Venn diagram to delineate the interconnections between mathematics and one other discipline. This can be used when the mathematics teacher and the science teacher can integrate the teaching of density, or the social studies teacher and the mathematics teacher can integrate the teaching of coordinate graphing and map reading. It is a good place to start integration because it requires less planning and less coordination.

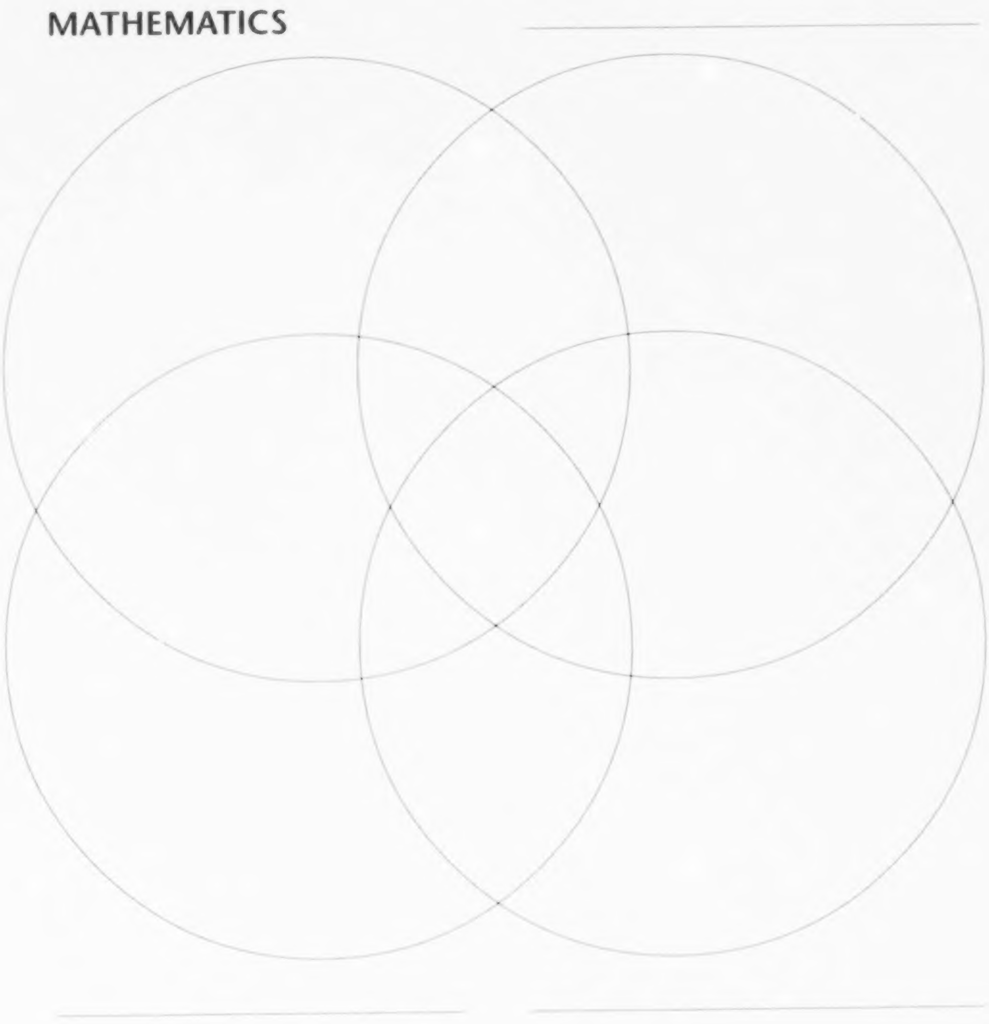
Three-Subject Venn



TOPIC: ____________________________________

Many of the interdisciplinary units in this book suggest that three teachers work together. While the language arts teacher has students read *Flatland,* the social studies teacher can examine issues of prejudice and discrimination and the mathematics teacher can explore a two-dimensional perspective in a three-dimensional world. Perhaps your integration project should begin with the involvement of three teachers.

Four-Subject Venn



TOPIC: ________________________________

If four teachers have brainstormed intercurricular relationships (perhaps social studies, science, mathematics, and language arts), then this model will meet your needs for delineation of skills and exploration of overlapping concepts. If there are more than four teachers who wish to participate in the integration of curriculum, experiment with a model that more clearly describes your intentions.

Teacher's Page

MATHEMATICAL CONNECTIONS

INTELLIGENCES

OTHER CURRICULAR CONNECTIONS

Science:

Social Studies:

Language Arts:

Other:

CONCEPTS

Students will do the following:

1.

2.

3.

(Continued on next page)

Teacher's Page (Continued)

MATERIALS NEEDED

PROCEDURES

ASSESSMENT

1. Student products—Successful completion of worksheet
2. Observation of students
3. Grading matrix
4. Journal question:

Grading Matrix

Name(s) ______________________________

Date ____________________ Class ____________________

Criteria	4	3	2	1

Comments:

Appendix B

Answers to Selected Problems

Chapter 1: Our Earth: Natural Disasters

Magnitude of Earthquakes, p. 21

1. 4
2. 2,512
3. 2
4. 4

Some Interesting Facts about Volcanoes, p. 26

1. Answers will vary.
2. 600 seconds, or 10 minutes
3. 375 mph

How Much Water?, p. 32

1. 3,459 sq mi x (30 x 17,371,520) x 8.3 = 1.5 x 10^{13} lbs
2. 261,914 sq mi x (23 x 17,371,520) x 8.3 = 8.7 x 10^{14} lbs
3. Answers will vary.

Some Interesting Facts about Tornadoes, p. 36

1. 4 hours, 30 minutes
2. Answers will vary.

Chapter 4: The Stock Market

The Dynamics of a Stock, p. 100

1a. 31 $^{1}/_{8}$, 22 $^{3}/_{4}$ = 8 $^{3}/_{8}$
1b. 61 $^{1}/_{4}$, 50 $^{7}/_{8}$ = 10 $^{3}/_{8}$
1c. 29 $^{1}/_{4}$, 16 $^{1}/_{2}$ = 12 $^{3}/_{4}$
1d. 32 $^{3}/_{8}$, 8 $^{1}/_{4}$ = 24 $^{1}/_{8}$
1e. 62 $^{1}/_{2}$, 41 = 21 $^{1}/_{2}$
2. AbbtLab

3a. 27.50, 27.125
3b. 59.125, 58.75
3c. 23.25, 22.50
3d. 8.25, 8
3e. 59.625, 58.75

Chapter 5: Quilting across the Curriculum

Jacob's Ladder, p. 128

1. 4 x $^{1}/_{18}$ = $^{4}/_{18}$ = $^{2}/_{9}$
2. $^{6}/_{36}$ = $^{1}/_{6}$
3. $^{10}/_{36}$ = $^{5}/_{18}$
4. $^{4}/_{36}$ = $^{1}/_{9}$
5. $^{4}/_{18}$ = $^{2}/_{9}$

Chapter 6: Out in Space

Rocket Altitude Records, p. 145

1. 10^{-1}, 7.1 x 10^{-1}
2. 1.25, 10^{0}, 1.25
3. 3, 10^{0}, 3
4. 5.2, 10^{1}, 5.2 x 10^{1}
5. 8.5, 10^{1}, 8.5 x 10^{1}
6. 1.18, 1.18 x 10^{2}
7. 2.44, 10^{2}, 2.44 x 10^{2}
8. 6.82, 10^{2}, 6.82 x 10^{2}
9. 8, 10^{2}, 8 x 10^{2}
10. 2.7, 10^{3}, 2.7 x 10^{3}
11. 7.07, 10^{4}, 7.07 x 10^{4}
12. 2.153, 10^{8}, 2.153 x 10^{8}
13. 2.42, 10^{8}, 2.42 x 10^{8}
14. 3.666, 10^{9}, 3.666 x 10^{9}

Are We There Yet?, p. 150

1. 1,690,909 hrs or 70,455 days or 193 years

Chapter 7: Our Human Body

How Much Blood?, p. 168

1. 15,750 gallons

Chapter 8: Physics and Formulas

How Fast Are We Falling?, p. 200

(Rounded to the nearest $^{1}/_{10}$ second)

2. 2.6
3. 2.9
4. 3.6
5. 3.2
6. 2.9
7. 2.3
8. 2.9
9. 2.5
10. 3.0
11. 3.1
12. 2.5
13. 2.4
14. 3.8

Box-and-Whisker Plots, p. 201

1. 25 %
2. 25 %
3. 25 %
4. 50 %
5. The range.
6. The smaller the quadrant, the closer the data.

Where Are the Roller Coasters?, p. 202–03

1. West
2. West
3. South
4. Midwest
5. Midwest
6. Midwest
7. East
8. Midwest
9. West
10. South
11. South
12. South
13. East
14. East

Chapter 11: Tiling and Tessellations

To Tessellate or Not to Tessellate?, p. 248

1. 1, 1 x 180, 180, $^{180}/_{3} = 60^{\circ}$
2. 2, 2 x 180, 360, $^{360}/_{4} = 90^{\circ}$
3. 3, 3 x 180, 540, $^{540}/_{5} = 108^{\circ}$
4. 4, 4 x 180, 720, $^{720}/_{6} = 120^{\circ}$
5. 6, 6 x 180, 1080, $^{1080}/_{8} = 135^{\circ}$
6. 8, 8 x 180, 1440, $^{1440}/_{10} = 144^{\circ}$
7. 10, 10 x 180, 1800, $^{1800}/_{12} = 150^{\circ}$
8. n-2, (n-2)180, (n-2)180, (n-2)180/n

Chapter 12: Designs in Regular Polyhedra

Platonic Solids, p. 259

1. 3 triangles
2. 6 squares
3. 8 triangles
4. 20 triangles
5. 12 pentagons

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